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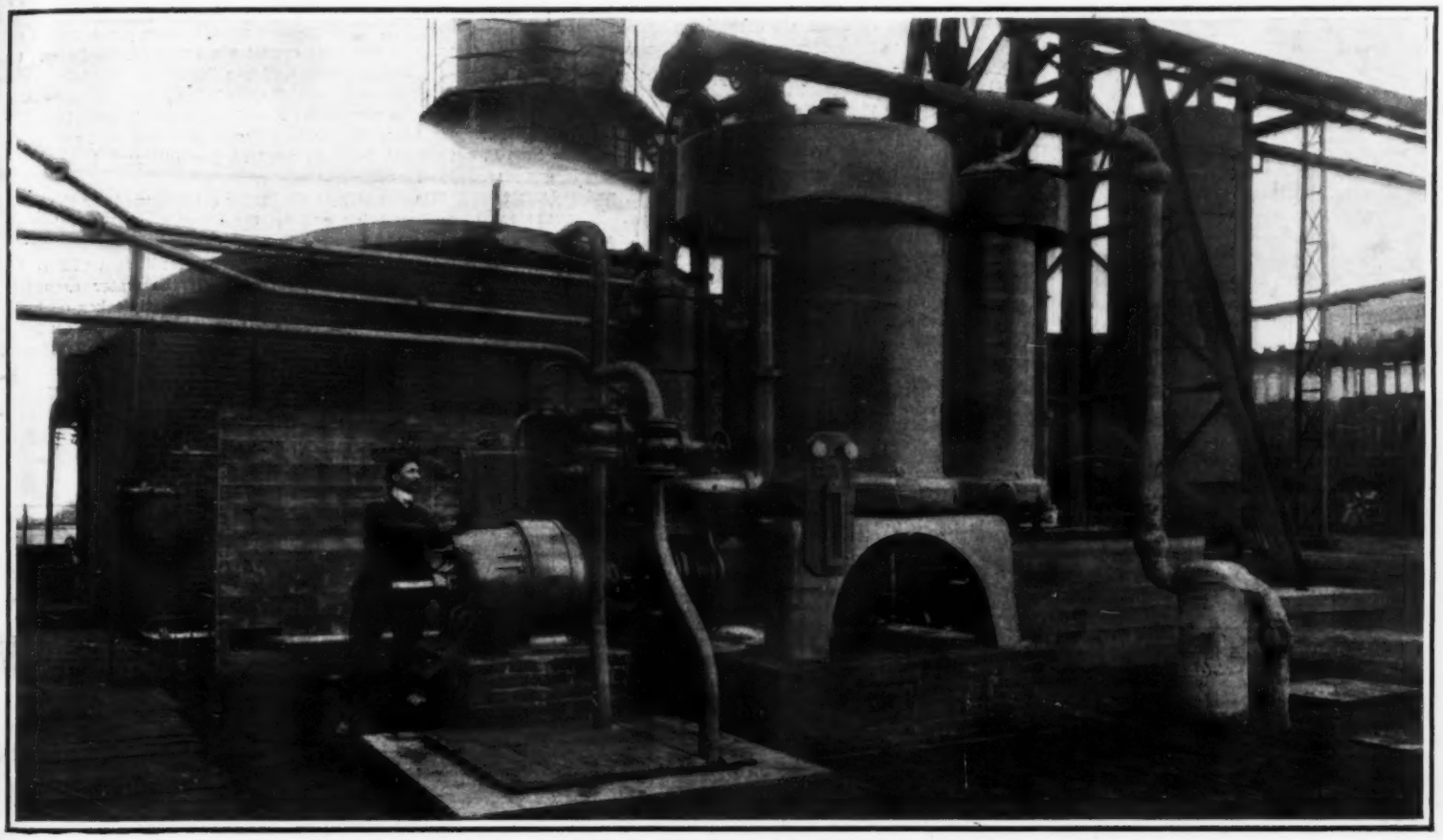


FIG. 4.—BETHUNE WORKS CONTAINING LEBLANC APPARATUS VIEWED FROM THE FRONT.

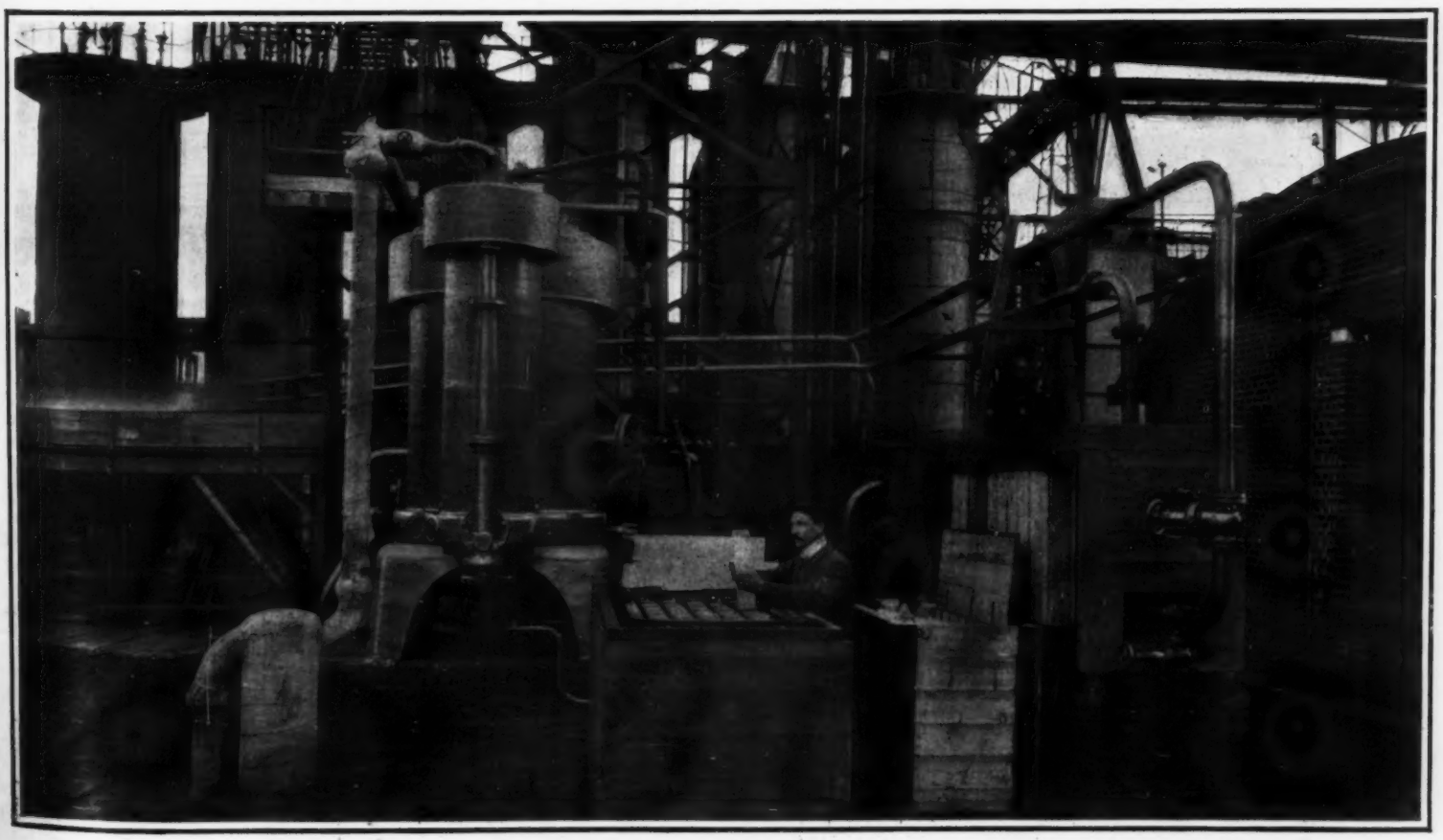


FIG. 5.—LEBLANC APPARATUS AT THE BETHUNE WORKS, FRANCE. SIDE VIEW, SHOWING ICE PLANT.

THE NEW LEBLANC REFRIGERATING APPARATUS

LEBLANC NEW REFRIGERATING PROCESS.

A NEW MACHINE ADOPTED BY THE FRENCH NAVY.

BY OUR PARIS CORRESPONDENT.

A NEW principle is used in the Leblanc refrigerating machine, and we wish to point out the advantages which can be obtained by the use of this apparatus, as well as to indicate the method of working. It is invented by a French engineer and is constructed by the European Westinghouse company. It will be noted with interest that the new system is being used by the French navy for some of the new battleships in

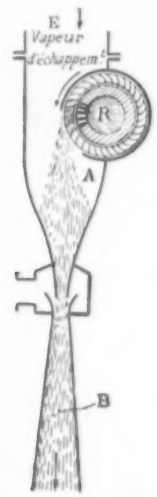


FIG. 1.—"CONDENSER PUMP" FOR USE IN SMALL PLANTS.

order to carry out the cooling of the ammunition storage quarters. Smokeless powder having nitrocellulose as a base is now recognized as likely to be decomposed at a high temperature, and when the heat is too great there will often be an explosion. This is stated to be the reason for the explosion of the battleship "Jena," as well as other vessels. Accordingly, the navy department is installing plants on board the new battleships such as the "Danton" and the "Voltaire," so as to give a circulation of cold air in these quarters.

We are familiar with the usual methods of cooling in a given locality, and this is generally carried out by the use of piping in which a non-freezing brine circulates. When the brine returns to the freezing machine it has been heated by a few degrees and the mâchine again lowers the temperature to the standard degree. In plants where the cold is produced by compressed and liquefied gas, this latter circulates in a worm within a tank filled with the brine, and the expansion of the gas within the worm causes the cooling

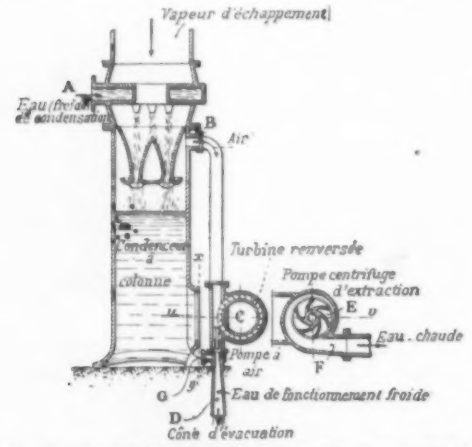


FIG. 2.—"CONDENSER PUMP" OF FIG. 1 PLACED OUTSIDE OF CONDENSER COLUMN. FOR USE IN LARGER PLANTS.

effect upon the liquid. Generally we use ammonia, methyl chloride or carbonic acid gas for this purpose. The new Leblanc system makes a new departure in using the rapid evaporation of water in order to secure the cooling. Water presents a distinct advantage, seeing that the ones just mentioned give a heat of vaporization ranging from 200 to 88 calories per kilogramme (2.2 pounds) at 0 deg. C. (freezing point), while for water the figure is much higher; this being 606.5 calories. For equal weight, water thus is much superior for cooling, but it has not been used in practice for practical plants, seeing that we must operate at a low temperature near the freezing point or below it. But here the vapor of water has a very low tension so that a small weight of such vapor occupies a great volume. This is not the case for the above-mentioned liquefied gases, seeing that their boiling point lies far below the freezing point of water.

To give a low enough temperature by the use of evaporation of water we therefore required to draw off a large volume of water vapor, and none of the present apparatus is suitable for such use. We will see how this is obtained in M. Leblanc's device. He uses the vacuum pump which he invented in the first place for use with steam engine condensers. Referring to Fig. 1, it is composed of an inlet cone *A* and an outlet cone *B*. In the upper cone is a reversed turbine working at a very high speed, and it delivers cold water from the upper to the lower part at a rapid rate. Exhaust steam from the engine enters at *E* and the steam is drawn off and condensed at the same time. Such a device is called a "condenser pump," and in such form it is used in small plants. For larger plants M. Leblanc prefers the apparatus shown in Fig. 2. Here the water is not delivered at high speed, but it enters at *A* and falls down in drops. The exhaust steam comes in from above. The same "condenser pump" as above shown is now placed outside of the condenser column at *C*, and it draws off the air saturated with vapor by way of *B*

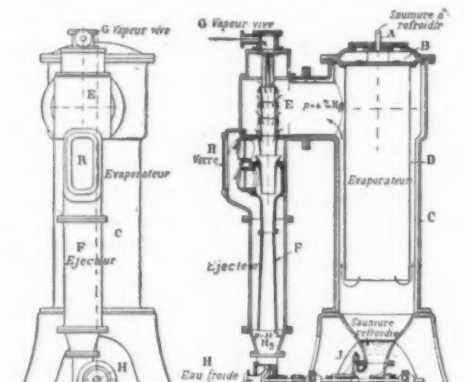


FIG. 3.—MACHINE FOR COOLING BRINE BY EVAPORATION OF PARTS OF ITS WATER BY VACUUM FORMED BY "CONDENSER PUMP."

and evacuates it at *D* along with the water coming from the turbine. A second pump of the usual rotary type, *E*, serves to take off the water from the interior of the column, and in practice the turbine *C* and pump *E* are both mounted on the same shaft so as to give a very compact plant.

The above system is applied to cooling machines in the following way: Instead of having the cooling brine cooled off by the evaporation of a liquefied gas, we now cool the brine by the evaporation of a part of its water alone, this being carried out by a vacuum formed by the "condenser pump." As shown in Fig. 3, the brine enters at the top at *A*, and a perforated plate *B* causes it to fall in fine spray in the evaporator *C*, in which the vapor is kept at a low pressure—1 millimeter (0.0394 inch) of mercury. Such partial vacuum is caused by the ejector *EF* and the "condenser pump" placed at *H*. The ejector is a perforated nozzle *E* in which is sent live steam from above, and the vapor coming from the brine is aspirated in through the small openings in the nozzle as shown by the arrows. Such vapor is diffused in a lower cone *F*, and it is condensed and taken off by the "condenser pump" placed below. At *J* is a pump for the circulation of the brine, and it works on the same shaft with the "condenser pump." Inside the column a jacket *D* is used so as to retain the spray and keep it away from the outlet pipe so that particles of water cannot be drawn off. The cooled brine collects at the bottom of the column and is taken off by the pump.

Our illustrations (Figs. 4 and 5) show the application of the Leblanc system at the Bethune mine and metallurgical establishment in France. It is here used in obtaining the benzol from the gas coming from coal distillation. Coke for metallurgical purposes is obtained from such distillation. In order to remove the benzol from the gas this latter is treated with tar oil, the oil being dropped in a shower from the top of a cylindrical tank, while the gas is sent in at the bottom in the usual way. The oil thus absorbs the benzol, but as it becomes heated by the gas it needs to be cooled by sending it through a worm cooler placed in a water tank. Means must be provided for cooling the water so as to keep it near 15 deg. C. (59 deg. F.). The present refrigerating plant serves this purpose and also operates a small ice producer. One of our views, Fig. 4, shows the two large main evaporating columns, one for the brine for the water cooling and the second for the brine which is used in the ice machine. Separate columns are needed here, seeing that the brine is used at two different temperatures for these two purposes.

On one side is the larger column used for the water-cooling brine and on the other a smaller column of the same type for the ice machine. Each column has a steam ejector of the kind we mentioned (*EF* in Fig. 3). Such steam, mixed with the water evaporated from the brine, is not however directly taken off by the "condenser pump," but it passes first into a condenser of the kind seen in Fig. 2. This condenser is common

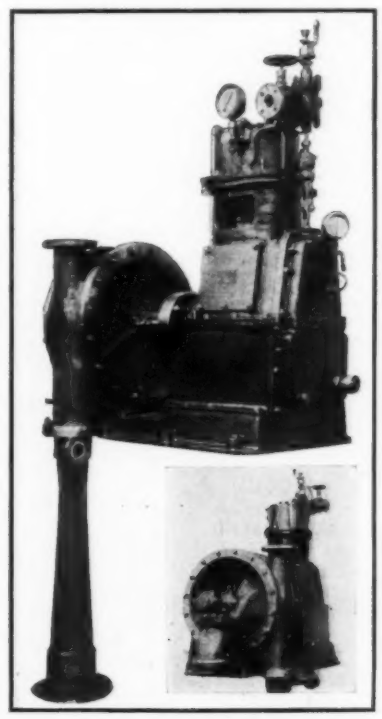


FIG. 6.—LEBLANC'S EJECTOR-CONDENSER ENGINE FOR RUNNING THE WATER TURBINE.

(See section Fig. 1.) View of Leblanc's ejector-condenser turbine in smaller engraving. Turbine is run by small engine here shown.

to both ejectors, and is seen on the left hand of the photograph, Fig. 4. Below it is the "condenser pump," which is the same as *C* in Fig. 2. Instead of live steam for the aspirating nozzles, there is used exhaust steam at about one atmosphere pressure coming from the different engines of the plant. The electric motor on the left serves to operate all the four pumps on the same shaft, these being the air pump for the condenser, the Leblanc "condenser pump," also the two brine pumps of the columns.

Referring again to the plants installed on the French battleships (Figs. 7 and 8), the main lines of these are as follows: An air current is sent through the chambers, and this air has a continuous circulation, returning to a cooling apparatus from which it is again sent out, this by the use of an air fan. The cooler is a chamber where the air passes along a set of wing tubes or hollow plates in other cases. The tubes and plates contain a cooling brine which circulates within them by means of a pump, and the brine is cooled in the same way as we have just seen, by an evaporating tank and steam aspirator, using the method employed at the Bethune works, that is, a surface condenser and then a Leblanc "condenser pump." What is special to the battleship plant is that it has a light construction in steel plate, and this is galvanized for all parts where the brine or sea water

comes in contact with it. In cold weather, sea water itself can be used for the cooling instead of the brine. Here the sea water is passed but once through the air-cooler, and is then returned to the sea, this by suitable piping. Four pumps worked by electric motors are employed here.

To illustrate other uses for which the new system is adapted we show (Fig. 9) a view of a plant recently installed in a large glue and gelatine works at Nanterre, France. Here we require the cooling of a gelatin solution so as to have it rapidly take the form of a jelly-like mass. The solution is run out on a long table in a thin layer. Over it is a strong air current, and the air works in a closed cycle, being cooled in a refrigerating room by a brine solution. The brine is kept cold in the same way as above, using an apparatus which is modified in some parts in order to suit the present needs.

THE TWO-CYCLE ENGINE.*

AFTER almost disappearing into the limbo of things forgotten the two-cycle engine seems to be awakening to a new life. In the quite early days of oil engines the Day cycle was invented. Whether Mr. Day was the true and original inventor we need not trouble to discuss; the cycle he used is known as the Day cycle, just as the ordinary four-cycle is called after Otto, though the honor is certainly due to Beau de Rochas. The Day engine, as everybody knows, had an exhaust port, which was overrun by the piston, and an admission port on the opposite side of the cylinder. A charge drawn into the crank chamber and compressed there to a few pounds, rushed through the admission port, impinged against a baffle on the piston, was deflected upward, and after striking the cover turned down again, driving the remains of the products of combustion out before it. Nothing could be simpler; no exhaust valves were wanted, and the admission valve on the crank chamber was a very simple thing. But the engine had its defects. First and foremost was the uncertainty as to the direction in which it would go. If automatic ignition were employed, as was often the case, a slight change in the mixture, some small hot spot in the combustion chamber, or the hot gases remaining in the cylinder, might cause premature firing, either pulling the engine up suddenly or starting it off in the opposite direction. The method of purging the cylinder was far from perfect. The incoming charge not only did not succeed in driving out all the products of combustion, but some of it itself escaped. The consequence was that the charge was weak from adulteration with burnt gases, and the economy bad because some of each charge was lost through the exhaust. Moreover, leakage from the crank chamber past the bearings, and so on, caused loss of fuel. Hence the engine, though apparently able to do twice as much as a four-cycle of the same cylinder volume, did nothing of the kind, and it showed little, if any, advantage in power for weight, and was certainly uneconomical. Later on, when the gasoline engine came into general use, the Day cycle, with various modifications, again came forward, and although it is not now used on cars, a good many small marine sets, mostly American, employ it. Here another disadvantage is liable to arise. A little gasoline finds its way into the crank chamber, with the result that the mixture becomes too rich, and the engine stops.

But, as we have said, in spite of all these troubles and disadvantages the Day cycle has continued to attract inventors, and it is actually coming back into use—of course in a modified form—with one of its old vices turned into a virtue. This virtuous-vice is no other than the old-time proclivity of the engine to reverse when it was not wanted to. By careful training it has now been taught to go backward only at request. As a result it promises to take a very important place in marine engineering, for the difficulty with the four-cycle engine has, of course, always been the complicated reversing gear. There have naturally been other modifications, most notable of which is an improvement in the method of exhausting. The overrun port is still preserved, but scavenging is effected partially or wholly by pure air admitted through special valves, or through a cylinder wall port as in the Day engine, instead of wholly by the new charge. Economy is thereby secured. In some cases, as, for example, the Diesel two-cycle engine, all chance of premature explosion is prevented, because the oil is not admitted until compression is complete. In the case mentioned it burns as in the ordinary Diesel cycle. The reversing of such an engine is effected with great simplicity. In the Peck engine the products of combustion are driven out partially by the incoming charge entering at the top, and partly by pure air from the crank chamber; in the Bolinders and other types the scavenging is effected by crank chamber air, and the oil is driven by a pump into the vaporizer some time during the compression stroke. In all these cases the waste of charge through the exhaust has been obviated, but it is not clear to what degree of perfection scavenging is carried. It is probably, at least in those engines which depend upon the piston baffle for the deflection of the air, not as complete as in the Otto cycle, and less power per stroke may therefore be anticipated. On the other hand, the great simplicity of the method has so much to commend it that minor disadvantages are outweighed. Moreover, the improvement in running effected by a better turning moment, permitting the use of a smaller fly-wheel, is a material point in marine engine design.

The two-cycle engine, it will be seen, presents, then, many advantages for marine work, but it still labors under one drawback. It depends in most cases, both for starting and reversing, upon the existence of a good supply of highly compressed air. The failure of the pump which supplies that air or of any connection between the air reservoir and the cylinders would render the engine practically useless. In Diesel type engines, of course, highly compressed air is necessary for the cycle, and is not quite in the same position as a supply employed for maneuvering purposes only. But even it could do with far less receiver volume, and would be simplified all round, if other means of reversing could be found. In one engine reversal is effected by slowing the engine, and then advancing the spark so that firing takes place before the dead point. This is a simple method, but some skill is required or the engine may stop altogether, and there is the further objection that the explosion takes place against a piston moving rapidly, and may set up heavy stresses. It is desirable to be able to stop and start the engine from rest in either direction with absolute certainty, and so far the only sound method of doing that is by the use of compressed air. There is room for invention to improve on it.

* The Engineer.

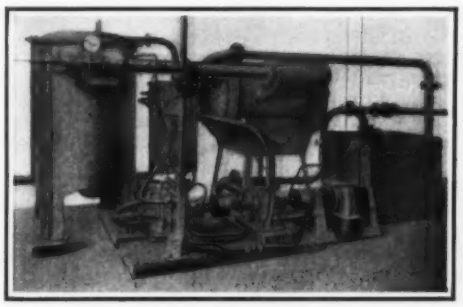


FIG. 7.—VIEW OF INSTALLATION FOR COOLING AMMUNITION STORAGE QUARTERS OF FRENCH BATTLESHIP "DANTON."

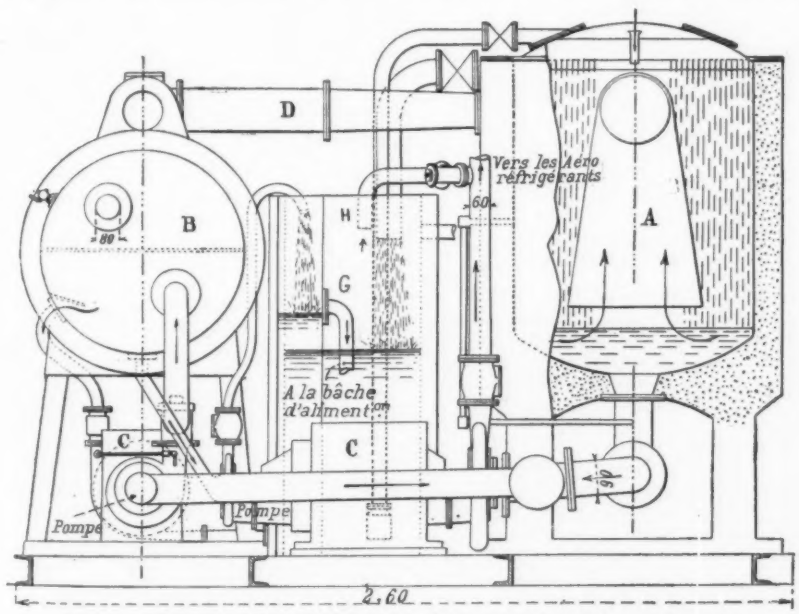


FIG. 8.—DIAGRAM OF COOLING INSTALLATION ON "DANTON."

A. Steel plate covered evaporator with perforated cover for falling brine. B. Conical hood for keeping out water from exhaust C, and a surface condenser as described in A B, Fig. 2.

RUBBER-SEED OIL.

IT was a long time before the oil of cotton seed became a valuable commercial factor. It is now believed that the oil of the rubber seed will in time be a marketable product and develop a profitable business in the Malay States.

At present there is such a demand for the Hevea seeds for planting purposes that the supply does not equal the demand. This office has received a request for 5,000 Para seeds to be shipped to the Philippine Islands, but the order cannot be filled until next October or November. The Botanic Gardens at Singapore, which is really the birthplace of the rubber industry in Malaysia, and which has furnished great quantities of seeds to the plantations, reports that it will not be able to furnish another 5,000 order of rubber seeds before next spring, owing to the many orders already booked. So rubber-seed oil is out of the question at present. The time is coming when there will be a large surplus of seeds from the 90 millions of trees already planted in the Far East, and then the rubber-seed oil will have its day and its valuable market.

It is now suggested by experts that, owing to the future commercial value of rubber-seed oil and the residue obtainable from local treatment, it would be wise in erecting new machinery on plantations or remodeling old machinery to make provision for power and space for the convenient placing of the rubber-seed crushing machines. This would leave the residue on the estates, which it is believed by experts will prove good for cattle food, as well as a valuable fertilizer. Scientific investigations of the commercial value of the Hevea seed have proved that they yield a fine, clear oil of good drying quality, not inferior to the best linseed.—From Consul-General James T. DuBois, Singapore.

It is reported in the American Machinist that the Union Pacific Railway has commenced a plan for increasing the efficiency of its men by means of a correspondence school. This school is intended for men of all grades, and its main object is to make them more capable in their present work, as well as to fit them for better positions. It is also arranged to allow for men to study for other departments in some cases, and the instruction is in charge of officers of the company. This should tend to bring the officials closer to the men, which is much to be desired in all cases.

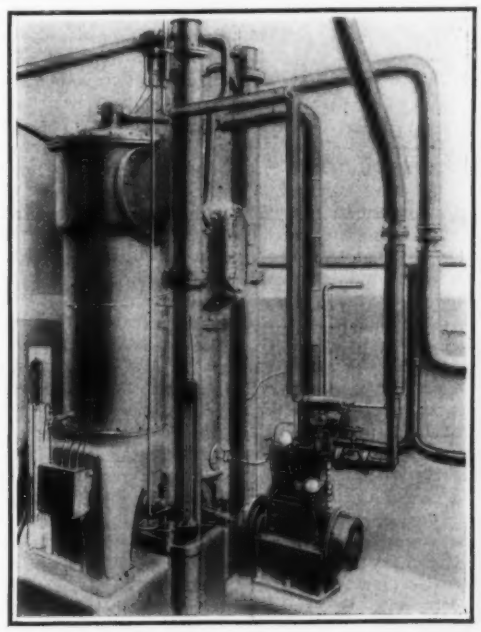


FIG. 9.—LEBLANC REFRIGERATING SYSTEM RECENTLY INSTALLED IN THE GLUE AND GELATIN WORKS AT NANTERRE, FRANCE.

AEROPLANE ACCIDENTS.

WHAT THEY TEACH THE DESIGNER.

The various accidents which have occurred recently to aeroplanes raise the whole question of whether the construction of the wings is such as to give the requisite margin of safety to insure their not breaking under the loads which are likely to come upon them in use. Up till recently the fatal accidents had mostly occurred in connection with biplanes, and there was never any suggestion that the cause of the accident was want of strength in the main wings. Lately, however, several accidents have occurred to monoplanes, in which there is good reason to think that the cause of the accident was the collapse of the wings in mid-air and of the consequent fall of the machine. It is, of course, very difficult in the case of aeroplane accidents to ascertain which part broke first, for the fabric is generally so utterly smashed by contact with the ground that no details of the first breakage can be seen. Further, the aviator, who is the only man who can tell accurately what happened, is generally killed, so that the only information available is what can be seen of the fall while the machine is in the air, and accidents occur so suddenly that different people do not always get the same impression of the sequence of events. There seems, however, little doubt that in several cases the wings collapsed in some way while the machine was flying, and that it fell in consequence. This feature is so important that it is worth while considering the whole matter of the strength of the main planes.

In the case of a biplane the framing of the main wings usually consists of four longitudinals running the whole length of the wings, and these are braced together, both vertically and horizontally, with numerous cross-struts and wire diagonals, so as to give them very great strength, both vertically and horizontally. In fact, if one works out the stresses of the diagonal wires, it is found to be very much below that usual in ordinary engineering work, and the wires are so numerous that, even if one of them breaks from vibration, the extra stress thrown on the adjacent ones will not bring the load up to the ordinary stresses allowed in girder work. The horizontal strength is also practically equal to the vertical, as the trussing is generally of the same character.

When we come to the monoplane, however, we find that the trussing is of a much simpler character, and further, that there is often no horizontal trussing at all. Figs. 1 and 2 show the front view and plan of the framing of an ordinary monoplane. It will be seen that the vertical strength of the main plane is entirely dependent on the stays, generally four each side, which go to the bottom of the strut under the backbone. Should one of these break, the probability is that the wing will collapse with disastrous results. In our issue of November 5th, 1909, we referred to the fact that these stays are often single parts of steel wire or ribbon, and that this is a material which has not been found sufficiently reliable for use as supports to the masts of small sailing boats, where wire-rope is always preferred, on account of the warning it gives before breakage. Wires in tension driven fast through the air are liable to vibrate in such a way as to deteriorate the metal, and it appears therefore that to trust to single strands is exceedingly risky; there is not this objection to the single wires on the biplane, as these are so numerous that one of them breaking should not endanger the structure. The risk in the monoplane could be avoided either by using wire-rope with a large margin of safety, or by having such a number of stays that a single one breaking will not endanger the whole structure.

A much greater defect in the wings of many of the monoplanes, however, appears to be the lack of horizontal strength. It is, no doubt, assumed that the weight of the machine rests on the wings, and that this is the main stress to be provided for. This is no doubt true, but a careful consideration of the horizontal stresses will show that these are much greater than might at first sight appear. When flying horizontally the horizontal stress cannot, of course, exceed the thrust of the propeller, and must in practice be considerably less than this, as part of that thrust is spent in overcoming the resistance of the body of the machine, the tail, etc. The ratio of lifting power to horizontal stress will vary considerably in different machines with the efficiency of the planes, but even with the machine flying horizontally the horizontal stress will probably be in the neighborhood of 10 per cent of the vertical.

It appears, however, that there are circumstances in which the horizontal stress may be very much greater than this, for it increases with the speed of the aeroplane through the air, and this may be very much greater when descending than when flying level. The wings contribute the greater part of the air resistance, and, therefore, if the aeroplane is descending, it will accelerate till the horizontal stress on the wings balances the acceleration due to gravity. Thus, if the aeroplane descends at a slope of one in five, the horizontal pressure on the planes may be approximately 20 per cent of the weight of the machine. If the engine is kept running, it will be more than this by the amount of the propeller thrust. It is quite clear, therefore, that circumstances might arise in which the horizontal stress would be some 25 per cent of the vertical.

Now, if we examine the framework of many of the monoplanes, we find that the horizontal strength of the wings is nothing like 25 per cent of the vertical; in fact, it is often probably under 5 per cent. The framework of the wing consists of two longitudinals, and

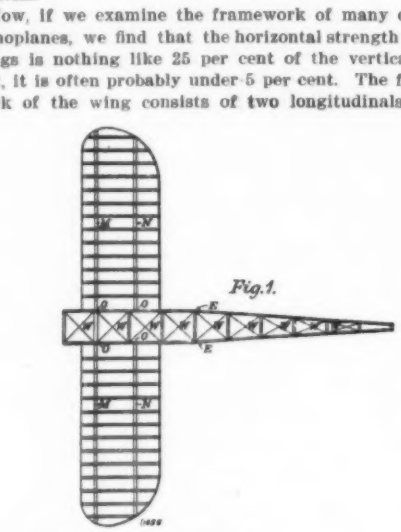


Fig. 1.

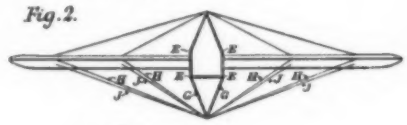


Fig. 2.

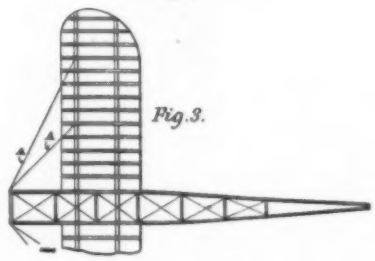


Fig. 3.

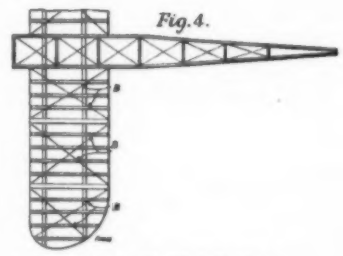


Fig. 4.

A TYPICAL MONOPLANE.

numerous cross-battens carrying the fabric. The longitudinals are the only part fixed to the backbone, and therefore take practically the whole stress. These longitudinals are generally made very deep in proportion to their height, and are often channeled on the sides to make them into I-section girders. It is obvious, therefore, that their horizontal strength is very small indeed compared with the vertical. True, the numerous cross-battens stiffen the wing perceptibly, but the extent to which this is the case can hardly be calculated; and as they are often only about ⅜ inch by ¼ inch, and fastened with very small nails, they cannot be relied on to any great extent. It seems, therefore, that either the wings should have diagonal bracing or should have stays in front corresponding to those down below. Where the backbone projects a long way in front of the wings, the latter method might be the simpler, as at *A A*, Fig. 3. Alternatively, diagonal wires may be run in the wings, as at *B B*, Fig. 4; and this is sometimes done—e. g., in the "Demoiselle." Another plan might be to make the battens themselves a diagonal trussing by having them at an angle to the main span, and making those on the top slope one way and those at the bottom cross them. This might, however, introduce difficulties in making the surface smooth enough.

That the question of speed in descent is a matter for which provision should be made is shown by the fatal accident at Rheims. The speed in this case would be higher than when flying level, and that in some cases the horizontal strength of the wings appeared to provide a very small margin for this increased stress, and the accidents seem to have happened exactly as suggested, for, in each case, when rapidly descending from a height the wings collapsed.

It may be said that when descending the engine should be stopped and the descent made at a speed not exceeding that which can be maintained on the level, but it is hardly practicable to stick to this, and if the aeroplane is to be of any practical use, it must be made to stand any reasonable usage to which it is likely to be subjected. Bicycles and motor-cars are often run down hill, or before a wind, at speeds far higher than could be maintained on the flat, and it is quite certain that a machine which is unsafe under these circumstances is not fit for ordinary work. Most men run down a hill as fast as they can without losing control of the machine, and aviators will doubtless do the same. The machines must, therefore, be made to stand the stresses set up under these conditions.—Engineering.

HOW IT FEELS TO FLY.

The Times correspondent at the Lanark Meeting was invited by Mr. Grace to share his ascent in a Farman biplane. The following is the record of his experience:

The first wind register showed the velocity to be from 25 to 30 miles an hour, but toward half-past 1 o'clock it dropped to 18 and 22. The competition for this period was weight-carrying round the course, each machine to carry 350 pounds. By virtue of my weight of 14 stone (196 pounds) I was invited by Mr. Grace to share his adventure in a wind that warned off all other competitors. The worst part of such a journey for the novice is the waiting until everything is ready for the start. The sensation of anticipation is not unlike the feeling that one has when one is waiting for a wounded boar to break cover from the corner into which he is driven. But once the propeller starts to whirl behind you all other thoughts beyond exhilaration of rapid motion vanish. You have gripped the struts thinking that you will have to hold on like grim death, but you immediately find that this is not necessary. The machine moves along the ground at an extraordinary pace, and I only knew that it was actually flying when I saw the elevating plane change from the horizontal. Of the motion of flight it is difficult to speak clearly. Even in the high wind that Mr. Grace was now climbing, it was not more than the sensation of a beautifully balanced motor-car. The earth—in this case the sward of the Lanark racecourse—seemed to be racing away from under us, and in a flash we were level with the first pylon and the judge's box.

The machine was now up to 150 feet, and I became engrossed in Mr. Grace's method in flying. It seemed to me that his attention was glued to his elevating plane, with just momentary glances out of his eye to judge the distance by which he had to shun each pylon in its turn. We were now crossing fields and water. I could observe the gates, the wire fences, and a man bathing in the water. Then we were round into the wind. Our pace immediately slackened, and Mr. Grace was working to keep his machine in the air. As we crossed a road we were going so slowly that I could observe the direction of the hoof marks of a horse that had recently passed. Here all observation ceased, as Mr. Grace was now battling with the wind. We had only 500 yards to traverse to cross the winning line, but the dead weight against the wind was bringing the machine down. Then there came a gust heavier than them all. It took the machine just up the requisite amount to cross the line, and we came gently to earth. It had only been a four minutes' ride, but it was certainly the most delightful ride that I had ever experienced. The only recollection that I have that will describe the general sensation is that of exquisite motion.—The London Times.

It is stated that Messrs. Vickers, Sons & Maxim are to lay down an experimental tank for testing ship models at their works at Barrow-in-Furness. Such a step should meet with well-deserved success. Many firms have considered doing the same, but at present only Messrs. Denny and Messrs. John Brown possess establishments of the Froude type, though the Parsons Company at Newcastle-on-Tyne have an open-air tank in which to try models. Probably other firms will eventually realize the advisability of laying down experimental plants, if only because of the saving possible in trial trip expenses, which in the case of new designs may often greatly exceed the cost of the scientific investigation that would have obviated them.

THE AERIAL TORPEDO.

AN OLD IDEA REVIVED.

BY LIEUT. JOHANNES ENGEL.

THE report that the Krupp firm has acquired an option on the patents of the Swedish Colonel Unge for aerial torpedoes, and the experiments which the firm has carried on with these projectiles, have reawakened interest in a weapon which possessed great military importance until the middle of the nineteenth century, namely, the rocket. The high estimation of the rocket, however, was made possible only by the inferiority of artillery in general, and it necessarily disappeared as soon as the value of rifled cannon had been recognized.

The rocket is the simplest device by which an explosive charge can be carried to its goal. Instead of

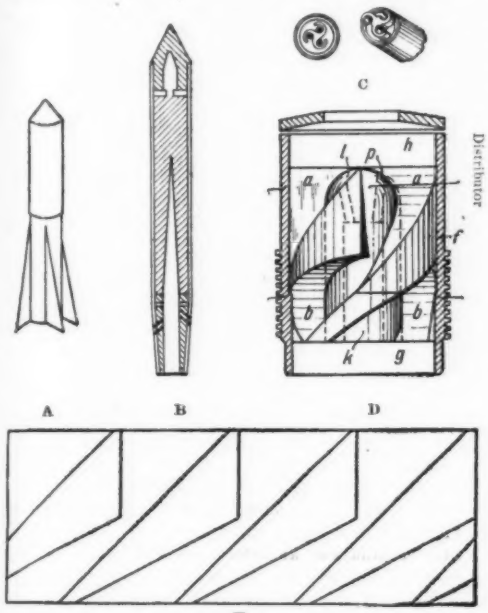


FIG. 1.—ROCKETS.

A, Rocket with inclined vanes. B, Hale's rocket with lateral gas outlets. C, After end of Hale's turbine rocket. D, Turbine. E, Section of turbine channels.

a heavy cannon, which requires horses for its transportation and a large crew of men for its service, the rocket needs only a light and inexpensive stand, from which it can be discharged by three men. As the propelling charge burns gradually, the propulsive effect is small at first, and increases during the first half of the flight. The rocket starts without the slightest shock, and consequently the walls of the head, containing the explosive charge, may be very thin, and a very large quantity of explosive can be carried, if it is desired to produce a conflagration or the effect of a mine. This freedom from sudden shock at the start also makes possible the employment of explosives which are more effective, but also more sensitive to shock than black powder. This principle was subsequently employed in America in the construction of the pneumatic dynamite gun. Little success, however, has been obtained with this arm. Freedom from shock is less important with modern explosives, which, though very powerful, are not easily exploded.

This gradual increase of velocity makes the efficiency of the rocket greatest at great distances, for the maximum velocity is attained at about the middle of the course. Beyond this point the combustion gases do not acquire sufficient pressure in the increased space left vacant by the combustion of the explosives to produce the same reaction as before. When we remember that rockets have attained maximum velocities of 700 feet per second and ranges of 4,000 to 5,000 paces, the great value of rockets in the time of their employment becomes apparent. The most serious defect of the rocket was its uncertainty of aim, in which respect it was inferior even to the smooth-bore gun. It was owing to this defect that the introduction of the rifled cannon quickly caused the rocket to be abandoned, except as a luminous projectile.

The uncertainty of aim was caused chiefly by the stick, which was attached to the head for the purpose of carrying the center of gravity as far back as possible, in order to increase the steadiness of flight. This addition, however, increased the total surface, and hence increased the air resistance and the effect of wind. When the rocket was directed against the wind its range was shortened, because the end of the stick was lifted and the head depressed, and in a wind blowing from one side the rocket was deflected toward that side. Deviations of 250 and 300 paces have been observed, with a moderate wind and a range of 2,000 paces. Numerous attempts were made to remedy this defect by substituting for the stick some device which would assure greater regularity of flight. For example, inclined vanes were attached to the after part of the head, for the purpose of causing the projectile to rotate in consequence of the pressure of the air upon these vanes. (Fig. 1, *A*.) With the same object, Hale in England constructed a rocket in which the gases escaped through oblique openings. (Fig. 1, *B*.) This device was subsequently improved by

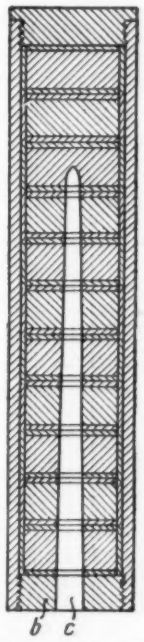


FIG. 3.—STRATIFICATION OF PROPELLING CHARGE.

substituting for the oblique lateral orifices a sort of turbine or screw at the end of the rocket. (Fig. 1, *C*, *D*, *E*.)

No appreciable improvement, however, was effected by these modifications, as the flight of the projectile was still influenced by the varying rate of evolution of the gas and the varying strength and direction of the escaping streams. Uniformity of these factors is required to produce steadiness of flight. The packing and pressing of the explosive in the propulsion chamber did not produce perfectly regular combustion, and

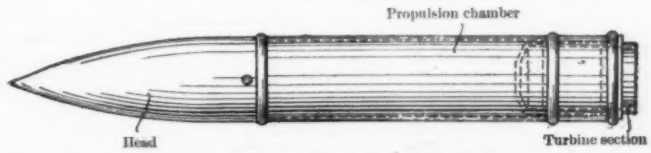


FIG. 2.—UNGE'S AERIAL TORPEDO.

the direction of the escaping streams of gas continually changed in consequence of the fusion of the metal around the orifices. The principal source of irregularity resides in the direct escape of the gas from the combustion chamber to the air.

Colonel Unge, therefore, added to his torpedo, immediately in front of the turbine, a reservoir, in which the gases collect and their pressure is equalized. The central stream of gas impinges upon a massive rounded obstacle, the distributor, which converts it into a hollow cylindrical current, and conducts it to the turbine channels. (Fig. 1, *D*.) These have the form of two wedges with their small ends in contact. (Fig. 1, *E*.) The inlets and outlets are so placed with reference to each other that no gas can escape in the direction of the axis. The current is checked at the smallest section of the channel, and thence the gas gradually expands in the outlet channel. The Unge turbine is operated partly by the impact of the outrushing gas upon the inclined walls of the inlets, and partly by reaction in the outlets. When the gas escapes directly, only a small part of its energy is usefully employed. The peculiar form of the Unge turbine economizes gas and combustible, and consequently produces an increased range, as well as a more uniform and regular flight.

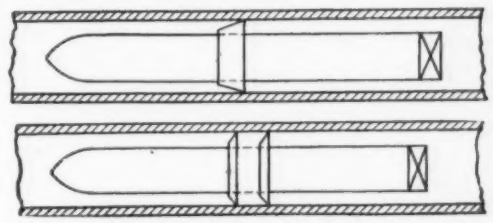


FIG. 4.—TORPEDOES WITH BALANCING RINGS IN FIRING TUBES.

The Unge torpedo (Fig. 2) consists of three parts —the head, containing the charge of explosive; the propulsion chamber, containing the charge required for propulsion; and the turbine section. The propulsion chamber is made of steel in the strongest possible manner, in order to prevent any deformation of its walls by the pressure of the gas or the formation, between the walls and the charge, of spaces into which the hot gases could penetrate and ignite the combustible. The increase in the surface of combustion produced in this way might increase the pressure sufficiently to cause explosion. The thickness of the wall should be proportional to the time during which it is in contact with gas hot enough to melt the metal. The wall is therefore thickest near the turbine and thinner in front. The propulsion chamber is separated from the explosive head by a gas-tight metal plate, and from the turbine segment by a perforated plate. The propulsion charge is composed either of common rocket powder (a mixture of sulphur, saltpeter, and charcoal), or of one of the modern smokeless powders, of such composition and structure that it burns regularly and produces a constant flow of gas. As sufficient pressure cannot be obtained by the gradual burning of the charge at the bottom alone, the surface of combustion is increased by a central perforation, so that the mass burns from the middle outward. (Fig. 3.) The maximum surface of combustion must bear a definite relation to the smallest section of the turbine channels. If this section is too large the gas escapes too rapidly, and its energy is not entirely utilized, while if the section is too small the pressure may become high enough to burst the propulsion chamber. The same result follows if the surface of combustion becomes, for any reason, too large in proportion to the outlet, for example, by the formation of cracks in the charge, or interstices between it and the wall of the chamber, owing to drying and shrinking of the charge or expansion of the wall by heat. For the purpose of averting such accidents the charge is packed in the propulsion chamber in layers separated by layers of felt, cloth, paper, or other elastic

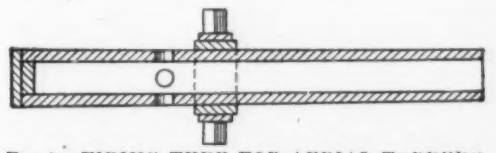


FIG. 5.—FIRING TUBE FOR AERIAL TORPEDO.

material of low thermal conductivity. (Fig. 3.) This packing can be protected from the effect of dampness by saturating it with oil. When the turbine is screwed on, the perforated plate is pressed tightly against the propulsion charge, slightly compressing the elastic packing.

In order to facilitate rotation of the torpedo in the firing tube it is surrounded, at about its middle, with a ring or rings of soft metal, copper, or brass (Fig. 4) of such diameter that contact of either end of the torpedo with the wall of the tube is prevented, even if the axis of rotation does not coincide exactly with the geometrical axis.

The turbine section is a cylindrical metal chamber

which is screwed on to the lower end of the explosion chamber and contains the massive distributor, which has the form of a cylinder with a hemispherical end. The turbine channels, of the peculiar form described above, wind spirally around this distributor. (Fig. 1, *D*.)

The explosion head is made of thin steel, is charged with one of the standard explosives used in shells, and is provided with a contact exploder. The head and the propulsion chamber may be connected in such a manner that they can be stored and transported separately.

The aerial torpedo can be discharged either from a firing tube, bearing a general resemblance to a cannon, or from a simple launching tube, in which no firing charge is used. The launching tube possesses the advantage of lightness, weighing only about 140 pounds for a torpedo of four-inch caliber. Hence, it is easy of transportation and independent of the character of the ground. The firing tube, also, can be transported and operated more conveniently and cheaply than a cannon of the same caliber, as it is comparatively light and requires a charge only sufficient to give the torpedo a small initial velocity and a definite initial direction. This charge acts only until the torpedo has passed a number of outlets which are placed behind the trunnions. (Fig. 5.) The escape of the gas produced by the firing charge enables the gases produced in the torpedo itself to act upon the turbine and set the torpedo into rotation before it has left the tube, at the same time increasing the velocity to a value which will keep the projectile in its course.

The aerial torpedo is designed to act solely as a carrier of an explosive charge. Owing to the thinness of its walls, the fragments produced on bursting do not cause any great destruction. The dimensions and weights of torpedoes and simple launching tubes of various calibers, with their approximate English equivalents, are:

Caliber	10 cm. (4 ins.)	20 cm. (8 ins.)	30 cm. (12 ins.)
Length of torpedo	90 cm. (35 ins.)	155 cm. (60 ins.)	245 cm. (95 ins.)
Weight of torpedo	19 kg. (42 lbs.)	134 kg. (295 lbs.)	420 kg. (926 lbs.)
Charge of explosive	2 kg. (4.4 lbs.)	12 kg. (26.4 lbs.)	40 kg. (88 lbs.)
Diameter of tube	25 cm. (10 ins.)	37 cm. (14.5 ins.)	50 cm. (20 ins.)
Length of tube	250 cm. (99 ins.)	460 cm. (181 ins.)	700 cm. (276 ins.)
Weight of tube	64 kg. (141 lbs.)	235 kg. (518 lbs.)	710 kg. (1565 lbs.)

The great weight of the torpedo, in comparison with that of the tube, proves its superiority to the cannon for certain purposes. The two arms, however, are not directly comparable. Rockets were employed only for special purposes and in situations in which the use of artillery was impracticable, owing to the inequality of the land, difficulty of transportation, etc. Military history offers numerous examples of advantages derived from the sudden appearance of rocket corps. In future wars, likewise, cases may arise in which the besieger of a fortress may find it preferable to use large aerial torpedoes, the launching tubes of which, though heavy, would be very much lighter than cannon of the same caliber. On the other hand, a corps equipped with small and light torpedoes might advantageously accompany the attacking column and facilitate the work of the pioneers by destroying wire fences and other obstacles. —Artilleristische Monatshefte.

THE ATOMIC WEIGHT OF RADIUM EMANATION.

Investigations have been made by many observers on the atomic weight of radium emanation, but the results are not very concordant. In a new investigation undertaken by A. Debierne, a modification of Bunsen's method of determining the density of a gas has been used, based on observations of the speed of escape of different gases through a small hole in the vessel containing them. In the experimental arrangement two glass vessels were separated by a thin sheet of Pt 1/100 millimeter in thickness, pierced with a very small hole. In one of the vessels was placed the gas under observation, while the other was connected to a continuously running Gaede pump. The pressure of the gas was measured by a McLeod gage, and it was found that the pressure decreased exponentially with time at a rate depending only on the density of the gas. Observations were made with mixed gases, and it was found that each gas escaped as though it were alone. The observations were extended to radium emanation, the equilibrium of activity being measured instead of the pressure, and the same laws were found to hold, the rate of escape giving a value of 220 (± 2 per cent) for its molecular weight. Assuming radium emanation to be monatomic, this value also represents its atomic weight, and is very near to that obtained from the disintegration theory by subtracting the atomic weight of He (4) from that of Ra (226.5).

Correspondence.

THE CONSTRUCTION OF AN OVAL.

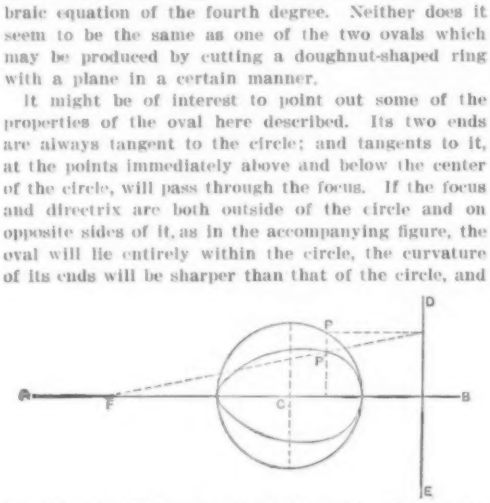
To the Editor of the Scientific American Supplement:

The article on constructing an oval, by Frank McLees, in your Supplement for July 30th, reminds me of another method, which I hit upon while a student at the University of Georgia about fourteen years ago, suggested, I believe, by some graphic method of determining the stresses in beams or girders.

Take a circle of convenient size (or with a diameter equal to the longer axis of the desired oval), and draw through its center a straight line, *AB*. At any point on this line erect a perpendicular *DE*, which may be called the directrix. Select a point *F* on the line *AB* for a focus. From any point, *P*, on the circle, draw perpendiculars to *AB* and *DE*. Draw a straight line from *F* to the foot of one of these perpendiculars, and the point where it intersects the other perpendicular will be a point on the oval. Any desired number of points may be located in the same manner; and it would not be very difficult to construct an instrument for drawing such an oval as a continuous curve, although such an instrument would be more complex than one based on Mr. McLees's method.

As I have no mathematical works here to refer to (and have not even looked into one for several years) I cannot tell whether this oval is closely related to any of those described by your contributor or not. Perhaps not; for its equation involves no trigonometric functions, being a comparatively simple algebraic equation of the fourth degree. Neither does it seem to be the same as one of the two ovals which may be produced by cutting a doughnut-shaped ring with a plane in a certain manner.

It might be of interest to point out some of the properties of the oval here described. Its two ends are always tangent to the circle; and tangents to it, at the points immediately above and below the center of the circle, will pass through the focus. If the focus and directrix are both outside of the circle and on opposite sides of it, as in the accompanying figure, the oval will lie entirely within the circle, the curvature of its ends will be sharper than that of the circle, and



the big end will be nearest the directrix. Moving the directrix away from the circle will make the oval narrower, and if the directrix were at an infinite distance it would narrow down to a straight line. If the directrix is brought up in contact with the circle, the oval will have the same curvature as the circle at that point. Now if the directrix be moved still farther to the left, all that part of the oval to the right of it will lie outside of the circle; and finally, if the directrix be placed between the circle and the focus, the oval will lie entirely outside of the circle (though still touching it at the same two points), and its axis will be its shortest diameter, instead of its longest as in the case of the egg.

Now let us see what changes are brought about by moving the focus. The farther off it is, the larger the oval, the limit of which in that case is the circle itself. (There does not seem to be any way of transforming the oval into an ellipse.) If the focus be brought up to the circumference of the circle, the oval will come to a point there; and placing the focus inside the circle will transform the oval into a sort of lemniscate, which will be symmetrical if the focus coincides with the center of the circle.

All of the shapes thus far described can be simulated pretty closely by those produced by Mr. McLees's method. Still further variations might, however, be produced by moving the line *A B* away from the center of the circle or the focus away from this line, or using some other angles than right angles in the construction; and these would probably have no counterpart in the methods described by your contributor. And I am not sure that they could be produced by cutting a cone with any sort of surface of single curvature.

In the above discussion I have not used exact mathematical language throughout, but any mathematician will be able to grasp the ideas I intend to convey, and perhaps to improve on them considerably. Such a curve as I have described may be well known, but I have never seen it mentioned anywhere, or found a mathematician who knew anything about it.

Tallahassee, Fla. Roland M. Harper.

Varnish for Violins.—Dissolve 45 parts of sandarac, 60 parts of mastic, 15 parts of elemi, 7.5 parts of dragon's blood in 300 parts of alcohol and then add 15 parts each of oil of turpentine and castor oil. After standing 14 days the varnish must be filtered.

CONCRETE PIPES FOR A TRANSMISSION LINE.

The Marseilles Land and Water Co., of Marseilles, Ill., is operating about 30 miles of 30,000-volt transmission line carried largely on concrete poles. The decision was made to place some timber poles in the line in order to determine the comparative value of the two types in service under the conditions presented. During the time that the line has been in operation almost three years, the concrete poles have given most satisfactory service. In a number of instances lightning has shattered the timber poles, while only one concrete pole has been struck. In this case the bolt entered the top of the pole and followed down the vertical steel reinforcement in the latter, coming out near the base. The only damage done was to chip a small piece of concrete out at the top and to make a similar break where the current left at the bottom. During the three winters the line has been in operation numerous other poles in the vicinity have been wrecked by sleet and ice storms, but this line has stood without a single case of damage on this account. Based on these very favorable results, the entire 14 miles of line has now been erected on concrete poles. Th standard spacing of poles adopted is 125 feet and 132 feet apart. The regular size of poles is 30 feet in length, 6 inches square at the top, and tapering uniformly to 9 inches square at the base. Where special conditions, such as the crossing of other pole lines, waterways, and the like are involved, the length of the poles is increased, the maximum being 60 feet. The mixture of concrete employed is normally 1 part of Portland cement to 5 parts of gravel, graded from sand to pieces that will pass a ¾-inch screen; these proportions are varied according to the character of the gravel. The 30-foot poles are reinforced their full length by six ½-inch high-carbon square rods, three placed in a plane 1.5 inch from one face, and the other three in a similar position near the opposite parallel face. In poles 45 feet or more in length two additional rods are inserted. Short lengths of extra rods are added in the lower part of all poles, in order to provide for the excessive stresses introduced near the ground. The poles are designed to carry a pair of 10-foot timber cross-arms, spaced 20 inches apart from the bottom of the upper arm to the top of the lower one. The upper arm is 5 inches from the top of the pole. The cross-arms are bored for the pins of three insulators on 36-inch spacing. Each cross-arm is attached to the post by means of a ¾-inch galvanized iron bolt placed through a hole cast in the concrete. It also is braced to the pole by means of an angle-iron brace bolted to the pole. At every angle in the line a pair of cross-arms is provided, the strain in each direction coming on the arm on the corresponding side of the pole. The line is not side-anchored on tangent, but at abrupt turns screw anchors and dead-men were set for guys placed to take the side pull introduced. Holes were cast in each pole for galvanized iron steps, which will be placed permanently on the taller poles above a 10-foot height, while on the regular 30-foot size steps will be inserted by the linemen as required.

LOW SALARIES OF ENGINEERS IN GERMANY.

An interesting article in Teknisk Tidskrift calls attention to the over-supply of technically educated men in the German industries and the resulting low wages paid to well-educated men filling the positions in the designing room and the laboratory. A young man, after having finished a four or five years' college course, often finds himself forced to accept a position with no pay at all for four or six months, with the promise that after that time his services will be compensated, provided he proves satisfactory. Others receive from $10 up a month, and a young graduate who receives 100 marks ($24) per month considers himself fortunate. It is by no means only for the first few years that the technical graduate finds himself so poorly compensated. There is a large class of these men whose salary never exceeds 200 marks ($48) per month. The same scale of compensation applies also to the great number of doctors of philosophy who have entered in industrial work as chemists. A monthly pay of 175 marks ($42) per month for a middle-aged doctor working in the laboratories of the large industrial companies is not unusual. These conditions are due to the enormous number of men who have, during the last few years, entered into industrial work. During the fifteen years from 1891 to 1906 the number of students at the higher engineering schools in Germany increased over 200 per cent, and is still increasing, while at the same time the number of students at the regular universities who devoted themselves to sciences and of whom the majority later on entered the industrial field, increased by 160 per cent. The number of students at the lower technical colleges during the same period increased by 130 up to 300 per cent. The conditions have become so acute that the Bavarian government has issued a warning to young

men against selecting the engineering profession on account of the over-supply of men in this branch.

These abnormal conditions have also created a system of industrial despotism unknown in America. It is not unusual that the young graduate in order to obtain a position is required to sign a contract in which he agrees that he will not enter into the employ of a competing firm during a period of from two to four years, or, in extreme cases, up to ten years, after the time of leaving the employer with whom this contract is made. The older employees are largely tied to their positions by the pension system of the employers. Another abnormal condition which may be mentioned is that an employee has no right to patent anything that has been conceived in connection with his employment, and the inventions which he makes are the property of his employer. His name, in fact, does not even appear in the patent application. In many cases access to the works is entirely denied any employee not directly working in the shops, and sometimes one will hear persons expressing their wish to see the works where for a period of five years they may have been working in the drafting-room or the laboratory.

ROPE-DRIVING.

THEIR ECONOMY AND EFFICIENCY.

BY J. STORMONTH.

THERE are certain features of rope-driving that need attention if difficult drives are to be successful from the point of view of giving little trouble, and costing little for upkeep. We assume that the grooves in all pulleys connected are cut equal in depth and to the same gage. The most satisfactory drives, as a rule, are those in which the pulleys are equal, or nearly so, in diameter. Should one rope be smaller in diameter than the others, with equal pulleys, the relative speeds are still alike. One rope may drive at 4 feet diameter and another at 47½ inches, and yet both pull together. It is when such drives as 25 feet to 5 feet are employed that troubles arise. Some have even a greater ratio.

In Fig. 1 a rope and groove are shown diagrammatically. To find the difference in depth of a 1¾-inch rope we give the following solution. The angle $C\ A\ D$ is 90 deg., $A\ B\ C = 22\frac{1}{2}$ deg., $D\ A\ E = 67\frac{1}{2}$ deg., and $C\ A\ E = 22\frac{1}{2}$ deg. The cos. $C\ A\ E = 0.9238 \times \frac{7}{8}$ for 1¾-inch ropes = 0.8083. The sine $A\ D\ E = 0.8083$ and the cosine $= \frac{8083}{3826} \times 9238 = 1.95 = D\ E$.

In the same manner $D\ E$ for a 1⅝-inch rope is 1.81, a difference of 0.14 inch = 9/64. The 1⅝-inch rope sinks 9/64 inch deeper into the groove than the 1¾-inch rope, and the effective diameter of the pulley with the former rope is 9/32 inch less.

Let us conceive of two ropes on the 25-foot to 5-foot drive. One new 1¾-inch rope drives at the 5 to 1 ratio. The other rope is worn to 1⅝ inch diameter, and its effective driving diameter on the pulley is 9/32 less than the 25-foot. To keep the ratio correct, the driving diameter of the small pulley should be less than 5 feet by 1/5 of 9/32 = 9/160. But the rope sinks into the groove 9/32, so that $\frac{45}{160} - \frac{9}{160} = \frac{36}{160} = \frac{7\ 1/5}{32}$ is the amount by which the diameter is less than the normal ratio of 1 in 5. The speed gained by the smaller rope is $\frac{7\ 1/5}{32} \times 3.14$ in one revolution. At a speed of 300 revolutions per minute the gain in speed when the small rope or ropes is driving is 67½ revolutions of the smaller pulley in one hour. This means that the smaller ropes, if possible, turn the 5-foot diameter pulley inside the larger ropes 810 times in 12 hours, and each of the larger ropes is therefore to some extent a brake.

Subjoined is a table showing by how much, in a drive of 1¾-inch diameter ropes, the smaller pulley is lessened in the ratio of driving diameter when 1⅝-inch ropes are used:

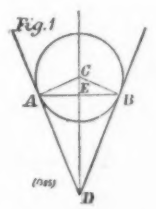
Reduction in 32nds	1 4/5,	2¼,	3,	4½,	6,	6¾,	7 1/5
Ratio of drivers	5,	4,	3,	2,	3,	4,	5
to driven	4,	3,	2,	1,	1,	1,	1

The effect of any of the smaller ropes driving is that the larger ropes sag on the underside. In practice a set of twelve ropes is placed, say, and after running a few days one of the ropes begins to hang on the underside, which we assume to be the driving one. This may be caused by irregular tension when the ropes are laid, by slightly irregular diameter of rope, or by unequal stretching before splicing. The rope runs round without pulling. The other eleven ropes do the driving and tightening themselves in the grooves, the slack rope is pulled taut on the top side sufficiently to still further stretch it. If the race be shallow, the rope is taken off, or, happily, it is re-spliced. If this is done so as to stretch the rope to the same diameter as the others, all may be well. But when a competent splicer is not at hand, it may lie off until the others need re-splicing. By that time the driving-ropes will be further reduced in diameter, and the relative difference between the ropes be further increased. Should the ropes drive a generator, the rope may merely lie off till the ropes are stretched and the generator is drawn back. But if the ropes stretch, they are slightly reduced in diameter, so that the odd rope will still be larger in diameter and will again hang on the underside.

When the ropes are driving light, and a number of them are driving on a smaller diameter than the others, the small pulley is drawn round within the larger diameter ropes. This sliding is then apt to proceed by fits and starts instead of at a constant ratio. One of the ropes is drawn taut on the upper side, then the pulley slides within it a few inches. The result is the rope, with the sudden release and slackening, surges upward. In these cases the rope or ropes may jump out of their grooves or even do damage.

It is obvious that in any ordinary drive from a larger to a smaller pulley, a new rope being placed with a worn set will simply act as a brake, the worn ropes driving the faster. Extra work is thus placed on the worn ropes and their lives are proportionally shortened. It is much better that the worn ropes should be allowed to wear out and a new set then be provided.

Let us suppose that eight new ropes are placed on a twelve-rope drive, and four of the old ones are allowed to remain. These four drive faster than the new ropes, but cannot overcome the new ropes. They therefore slide in the grooves, the eight new ropes determining the speed. As the old ropes slide, their spiral lay tends to make them revolve, and they rapidly wear out.



Drives may be seen in which the ropes revolve sufficiently to keep them round, and yet run for years. In ordinary circumstances the ropes become V-shaped, but when the ropes slide over the grooves they both revolve and wear rapidly. Rubbing the ropes with one or other of the graphite compounds enables the ropes to slide, and steadies a drive where the ropes are pulling unequally. The effective grip on the pulley is necessarily lessened. If much sliding takes place, the ropes will wear the grooves, damaging the drive irreparably unless the pulley is again turned. It is on the small pulley the sliding takes place, as the arc of contact is greater on the large pulley.

The difference of ⅛ inch in diameter may be said to be excessive in the case of a recently-spliced set. But 1¾-inch ropes are sometimes reduced to 1½ inch in diameter in less then twelve months. On the other hand, when the ratio is not great the ropes have a tendency to automatically adjust themselves, and this may often be aided by wise handling of the ropes. Where the dividing line takes place, where on the one side the ropes get worse, and on the other side get better, it is difficult to say, and obviously varies with the special circumstances. Let us say the drive is 2 to 1, and that four ropes are 1⅝ inches and six are 1 11/16 inches in diameter. The latter sink about 1/32nd in the groove and drive. The rubbing of the pulley within the larger ropes reduces these slightly—it may be by veeing them—and they begin to pull together. If the majority of the ropes are larger, then the smaller ropes slightly slide, and, in sliding, tend to revolve, owing to the lay-up of the ropes. This sliding in the spiral lay makes the rope practically longer, and adjustment is again secured. If this adjustment does not take place, then, as already shown in the case of old and new ropes, the smaller ropes are rubbed to destruction.

When ropes are much veed they deteriorate rapidly, as a rope cannot drive with a ¾ vee. The larger part of the vee cannot drive at the same speed as the smaller, and a constant ruffling of the surface of the vees takes place accordingly. If the center line of the rope is the neutral axis, we may expect the bottom of the vee on any rope to be compressed, as it is at the bottom of the groove. This is what takes place, the bottoms of the vees on the rope or ropes showing a crushed appearance on the surface. It is notable that ropes markedly veed are soft and limp on the part of the rope which is outside, as if the ropes worked on the neutral axis as on a horizontal hinge. Ropes which revolve become smooth, and even hard, on the outside.

Assume that the smaller pulley drives the larger at the same ratio as before—5 feet to 25 feet—and that the drive is one of six ropes, four of which are 1⅝ inches and two are 1¾ inches, as before. The smaller ones do the driving at a slower speed necessarily than would be the case if the larger ropes drove. The pulley is therefore turned within the large ropes, which are thus reduced by wear. Or, what is more common, the two larger ropes are caused to revolve so that ⅞ inch more rope is given off at each revolution; but being given off on the spiral, the net length is ⅞ inch less. The actual speeds are thus equal, and the proportions hold for the larger pulley also.

When single ropes are led to driven pulleys on different floors or on different drives, the troubles referred to are avoided. And when the various drives are of two, three, or four ropes, the difficulties are proportionately minimized.

The action of centrifugal force at high speeds is both disadvantageous and complicated. The action on a rope-drive is not the same as on a rope, let us assume, revolving in space, for in this latter the stresses are practically uniform, excluding gravity. At *D*, Fig. 2, the tendency of the rope to descend vertically is overcome by the pull of the rope *A B*, a pull which is uniform along its length, and which is the driving tension plus the pull needed to overcome the centrifugal force from *D* to *B*. The centrifugal force from *A* to *C* lessens the grip of the rope at that part, and if we roughly assume it to be equal to the centrifugal force at *D B*, then the grip of the rope at *A C* is the grip due to the driving tension only. The large pulley, owing to this and to its larger arc of contact, is not the one on which the ropes will slide. If we now examine *E F*, the slack side, it is apparent the centrifugal force at *E* is so far counteracted by the weight and tension of *E F*. But at *F* the tendency is for the rope to overshoot the pulley, thus lessening the arc of contact *F B*. In belt-driving on a small pulley, from another pulley at an angle above it, this effect is quite evident, the beholder being able to see between the belt and the pulley at the running-on side of the small pulley. Should *F D B* be a generator with the ropes at 5,000 feet per minute, the ropes at *E F* may dance at the high speed and on a light load. The tendency is to tighten up the generator and probably stress the ropes severely.

The reader may see that if the small pulley is at a convenient driving angle above the large one, the force of gravity counteracts so far the centrifugal force as regards the small pulley. And as 1½-inch diameter ropes are approximately three-fourths of the weight of 1¾-inch ropes, they are better for fast drives, their lessened weight giving less centrifugal force.

Should there be irregular turning moment in the engine, due, say, to excessive compression, the effect may be visible in the tremor of the ropes. Slack ropes on a light drive at starting will sometimes behave very erratically till the load is applied, when they will run smoothly. The solution, the writer thinks, lies in the fact that the driving tension being light, the ropes are not tightened in the grooves of the driving pulley, and any slight variations in diameter of the ropes causing tension and release on various ropes, as already pointed out, causes swinging and flying in an alarming fashion. When the ropes are tightened by the load, the revolving action, with its adjusting effect, takes place, and smooth running results.—Engineering.

Zinc is often used to prevent the corrosion of boilers. Its efficiency is due to the fact that any metal with a greater tendency than iron to dissolve on which hydrogen is liberated with more difficulty than on iron, will protect the latter at the expense of the more soluble metal. The protection, however, becomes ineffective in pure water at a distance greater than an inch. Salt or some other electrolyte will extend the zone to 20 inches or more.

THE PHYSICS OF DIVING.*

THE CURIOUS EFFECTS OF WATER PRESSURE.

It is necessary before discussing the effects of deep diving on the human body to review very briefly a few of the physical properties of air and water.

If a pint measure be standing empty in the air, every square inch of its surface, inside as well as outside, is being pressed on by the air with a pressure of, roughly, 15 pounds.

This is the amount of pressure that the atmosphere all around us approximately maintains on everything near the surface of the earth. It is due to the weight of the miles of air overhead pressing down toward the surface of the earth.

This pressure of 15 pounds on the square inch that the atmosphere exerts is called "atmospheric pressure," or the "pressure of one atmosphere."

Such pressure is not usually shown by a gage, since gages generally register a pressure in excess of that which is always present due to the atmosphere. There are, therefore, two ways in which pressure can be reckoned—first, that which includes the pressure exercised by the atmosphere, this is called "absolute pressure"; and secondly, that which does not take the pressure of the atmosphere into account; the latter is that generally shown by gages, and is usually talked of as "pressure."

If now the pint measure be closed at the top, and another pint of air be forced into it, there will be a double quantity of air in the measure trying to force its way out in all directions; the original pressure will therefore be doubled, and there will be an absolute pressure of 30 pounds on the square inch inside the measure on the top, bottom, and sides; but, of course, only 15 pounds "pressure" above that of the atmosphere inside the measure.

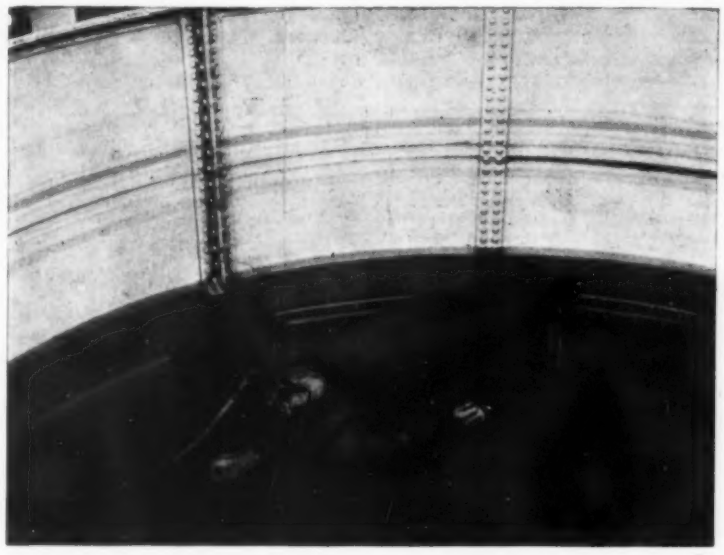
The same result could have been obtained if an India-rubber ball containing a quart of air had been pressed on from the outside, and the ball squeezed in until its capacity had been reduced to one pint. A quart of air (that is, two pints of air) would then be held in one pint of space, and the pressure inside it therefore doubled. It is convenient to use the word "volume" to express the quantity of air in any receptacle at atmospheric pressure. The following simple rule can, therefore, be used, viz.: If one volume of air is present in a receptacle, the pressure is atmospheric pressure, or 15 pounds absolute pressure. If *above* atmospheric pressure is required, we have merely to divide 90 by 15 to see how many volumes of air, in addition to the one already present due to the atmosphere, must be forced in. In this case six more volumes will produce a pressure of 90 pounds on the square inch above atmospheric pressure. These facts constitute what is called "Boyle's Law," which is that the volume of gas varies inversely as the pressure, while the density varies directly as the pressure. It is not necessary for us to complicate this simple rule by dealing with the exact effect of changes in temperature of the air; but it is well to remember that if the temperature of confined air is raised the pressure will be increased, and if the temperature is lowered the pressure will be decreased.

When dealing with water totally different conditions arise; since water cannot be compressed, it is, of course, a practical impossibility to force a quart of water into a pint measure. Another important consideration is that water is very much heavier than air, and that, although when dealing with ordinary quantities of air we may neglect its weight, we cannot do so where water is concerned.

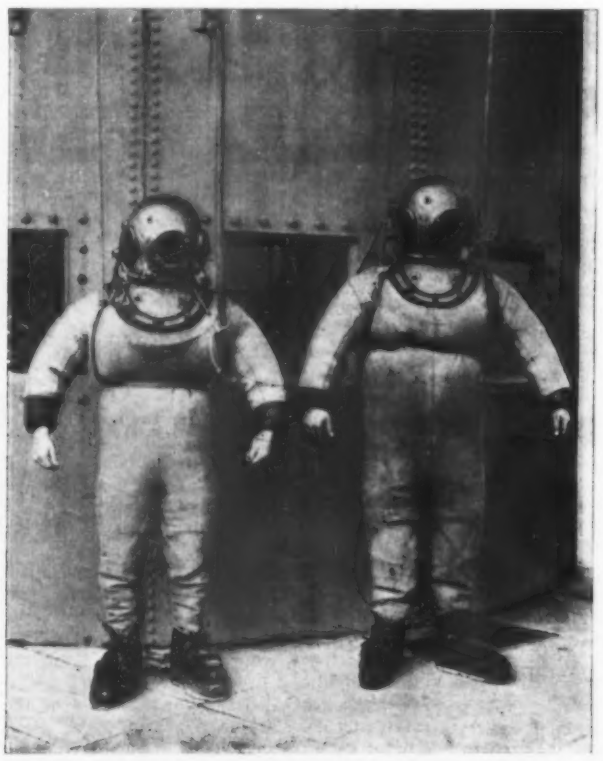
If a pint measure be full of air we can neglect the weight of the pint of air on the bottom of the measure, but if it be filled with water we cannot neglect the weight of water on the bottom. It is obvious that if a cubic box be filled with water the bottom of the box has to support the whole weight of the water, but the top has no weight of water to support; the pressure therefore on the bottom will be greater than the pressure on the top by an amount equal to the weight of water in the box. It is also obvious that the higher we raise the sides of the box, still keeping it filled up, the greater the weight or pressure becomes on the bottom.

A column of water 33 feet in height presses on the bottom of the column with a pressure of about 15 pounds on the square inch. This is the same pressure as is produced by one atmosphere of air, or a column of air the height of the atmosphere. Sixty-six feet of water would produce at its base a pressure of about 30 pounds, or the same as two atmospheres, and so on. In other words, every one foot in height of salt water produces a pressure of a little under ½ pound on the square inch.

It must be remembered that the atmosphere is also pressing down on top of the column of water, so that



THIS DIVER HAS PURPOSELY BLOWN HIMSELF UP IN THE ORDINARY DIVING DRESS. HE IS UNABLE TO MOVE HIS ARMS AND THE AIR CANNOT ESCAPE AS HIS OUTLET VALVE IS BELOW THE WATER.



DIVING DRESSES FULLY INFLATED WITH AIR. THE ONE TO THE LEFT HAS LACED-UP LEGS, THE OTHER DRESS IS OF THE USUAL PATTERN.

THIS DIVER HAS BLOWN HIMSELF UP IN THE NEW PATTERN DIVING DRESS WITH LACED LEGS. HIS HEAD IS UPWARD AND HIS ARMS FREE.

Two volumes are forced in, the pressure is doubled. If three volumes, the pressure is trebled, and so on. Further, if it is desired to obtain any given pressure of air in a receptacle, it is only necessary to force in a certain number of volumes of air to obtain it. For instance, if a pressure of 90 pounds on the square inch

* Abstracted from "Submarine Appliances and Their Uses, etc.," published by Siebe, Gorman & Co., Ltd., Submarine Engineers, London.

a column of water 66 feet in height would have at its base an *absolute* pressure of 30 pounds due to its weight, plus 15 pounds due to the atmosphere, or a total of 45 pounds *absolute* pressure.

The same holds good when considering the pressure on a body immersed in water. Any such body may be looked on as having the column of water between it and the surface pressing down all around it. This pressure is transmitted to the body in the form of a squeeze. Of course, if the body has appreciable length, such as a diver standing upright, the top of the body is nearer to the surface of the water than is the bottom, therefore there is less water above the top of the body than above its bottom, and therefore in the case of the diver there is less pressure on his helmet than on his boots. If the diver be 6 feet high there will be about 3 pounds less pressure on his helmet than on his boots, whatever depth of water he may happen to be in.

We are now in a position to see the connection between the pressure of the air inside a diving dress and of the water outside it. A diving dress has essentially two portions, a compressible dress and an incompressible helmet. As the diver descends the pressure increases, and tries to squeeze the air out of the dress into the helmet. If we wish to keep the upper part of the dress over the man's chest inflated, air must be pumped into the helmet and the upper part of the dress until the pressure of air in the dress is equal to that of the water at the level of his chest. As the man breathes, the air gradually becomes foul; fresh air must therefore be pumped in for him to breathe. If no escape is provided for the air from the dress, the pressure inside the dress would get higher and higher, and there would be more pressure inside the dress than outside it, which for several reasons would be very objectionable. An escape valve for this surplus air is therefore fitted. This escape valve works so that when the pressure inside the valve is greater than that of the water outside the valve, it is forced open and the extra air escapes. At first it seems as if the proper place for this valve would be at the same level as the man's chest, since it is the pressure at that level which is required in the dress; but many practical considerations lead to placing the valve at the back of the helmet. Since, when the man is standing upright, this spot has a pressure about ½ pound less than exists at the man's chest, a spring is fitted to keep the valve shut until the pressure inside has risen about ½ pound more than that of the water outside; by this means air is kept in the dress over the man's chest, although the valve itself is a little nearer the surface of the water. This valve can be adjusted by the diver to suit his convenience. This is very necessary, since a diver often lies down, when the relative depth of his chest and the valve is altered. Also, it makes a very great difference to the diver if the exactly right inflation of his dress is obtained. If the dress is too much inflated he becomes uncomfortably buoyant, and if too little inflated the weights bear heavily on his chest. It is, moreover, much less exertion when breathing inside a small space to have an elastic bag attached to it, like the inflated part of the dress, than to breathe inside such a space with rigid walls like the helmet alone, since the elastic part "gives" to each breath and keeps the pressure constant. The lungs also are only designed to work comfortably when the pressure inside and outside them is exactly the same; very little additional pressure outside them greatly increases the labor of breathing. As regards the remainder of the body, the pressure of the air at the mouth is instantly transmitted to the whole inside of the body. So that whatever depth the diver may be in, provided a proper air supply is maintained, the pressure outside the body can never be more than a pound or two over that inside the body. It must be remembered that air cannot be supplied to the inside of the dress by the pumps at more than a certain rate, hence, if for any reason a diver changes his depth at a greater rate than that at which the pumps can supply him with the proper pressure, he may be subjected to a very dangerous squeeze from the water.

The following illustration will emphasize this:

Suppose a diver at work on a stage cleaning the ship's bottom slips off the stage and falls 5 fathoms, owing to carelessness on his part, and culpable neglect on the part of his attendants to hold on to the life line and air pipe. At this depth the absolute pressure is twice as much as it is close to the surface, so by the descent the volume of the air in his dress is halved. He has an additional pressure of nearly 15 pounds suddenly applied to every square inch of his body, or about 2,000 pounds to every square foot. As the helmet is rigid, his body will be crushed into it with overwhelming force. He may be killed, he certainly will be severely injured, and there will be bleeding from the lungs, mouth, nose, etc. If, however, the diver is at 165 feet (27½ fathoms) and falls 5 fathoms, pressure has only increased in the proportion of seven to six, and the volume of air has only diminished by less than one-seventh of its volume, so that the effect will be proportionately less. From this it follows that the deeper a diver is the less serious is a fall.

The danger in falling is due to the sudden diminution in the volume of the air; sudden ascents may be just as dangerous. A special danger of a sudden

BACK VIEW OF DIVING DRESS WITH LEGS LACED UP.

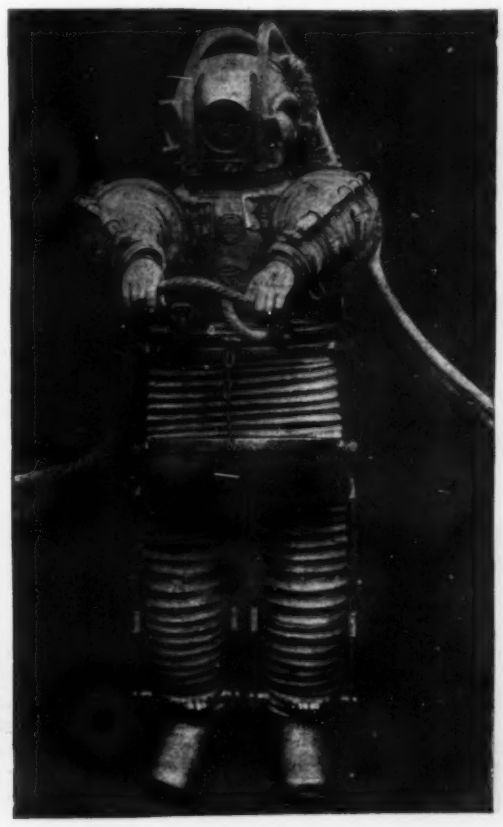
ascent is associated with the absorption of the air by the blood, and will be considered later. A diver in preparing to ascend tightens up the valve to increase his buoyancy and allows himself more or less to float up the shot rope. If the valve is closed more than will allow the excess of air to escape, his ascent will, at first, be gradual, but soon, with each foot of ascent, the volume of air in the dress expands and his speed is quickened. At first the limbs are more or less capable of movement, and the diver has a chance of holding on to the rope and adjusting his valve, but very soon the dress becomes so very much expanded that it is as hard as a board, and he cannot reach the valve; he is practically powerless. If the dress were to give way anywhere near the head under the strain, which fortunately is very unlikely, since the air always escapes through the cuffs, the diver might be in a still worse predicament, for if the attendant failed to haul in the slack of the life-line quickly enough he might sink like a stone, and be crushed by the pressure due to the depth he had fallen.

One other effect we have to notice is the pressure on the ears. The ear may be compared with a cavalry drum, which has a parchment covering at one end only. If we were to place such a drum in a caisson or other air chamber, and pump in air, we should very soon find that the head of the drum was being forced in; but if we made a hole in the body of the drum there would be no change, since the pressure on the inside would always be equal to that on the outside. The condition of the ear is the same as that of the drum. The middle ear is the body of the drum, and across one end is stretched the "drum" of the ear; at the other end is a tube which leads into the nose and allows the air pressure on the inside of the ear to become equal to the pressure outside. But often, from a slight cold or other cause, the tube leading to the nose becomes blocked up, and we have pains in the ear until the passage is cleared. In the case of a diver this is best done by stopping in his descent for a moment and swallowing his saliva, as the action of swallowing opens the tube. If he cannot open the tube he must come up again. Usually, if the diver can reach five or six fathoms he will have little difficulty in attaining greater depths, where the relative differences in volume of the air become less and less.

The effect of the law of pressure on the work of the pump can be considered here. As the diver requires the same *volume* of air at whatever depth he may be, if the pumps are taking in one cubic foot a minute when the diver is near the surface, they must take in two cubic feet when the diver is at 33 feet, three cubic feet at 66, four cubic feet at 99, and so on. But not only have the pumps to take in and deliver a much larger quantity of air; they have also to deliver it against a rapidly increasing pressure, so that the work is greatly increased.

We saw that the density of the air increased with the pressure; this leads to certain effects in connection with the voice, which at very great depths has a "Punch"-like quality, which is very distinctly noticed through the telephone. A diver cannot whistle when in deep water, as the density of air hinders the vibration of the lips.

NO. 1



NO. 2.

These illustrations show two of the many different forms of diving dresses which have been designed with a view to their withstanding the water pressure at great depths without a corresponding pressure of air inside to balance, as in the case of the ordinary diving dress. No. 1 is from the designs of a Frenchman; No. 2, which is the more practical, from those of two Australians named Buchanan and Gordon. The latter suit is made in two parts—the upper consisting of head and body of stout copper, the arms and lower half of the dress (excepting the thigh part, which is also of copper) consisting of a series of special metallic springs covered inside and out with very strong waterproof material. The arms are fitted with spiral springs and the legs with jointed supports to prevent the water pressure forcing them upward. There is also an arrangement by which the suit can be adjusted to the height of the diver. The dress is fitted with two valves—the inlet or air supply valve and the outlet or air escape valve—both being under the control of the diver. To the escape valve is connected a floating pipe, the upper (open) end of which can be submerged to any required depth below the surface, thus allowing the air to escape more freely and enabling the diver to regulate the air pressure in the dress with greater facility. The weight of the dress is about 3½ cwt.

THE PHYSICS OF DIVING.

THE STATUS OF PROCESS INVENTIONS.*

A PATENT LAWYER'S VIEWPOINT.

BY E. D. SEWALL.

THE laws of the United States provide for the grant of a patent to any one who has invented any new and useful art, machine, manufacture or composition of matter. An "art" within the meaning of the patent law is a way of accomplishing a result—a process, or a method.

The patent laws do not extend protection to all inventions. The Constitution authorized the enactment of such laws "to promote the progress of science and the useful arts." It is therefore clear that the subjects of invention for which patent protection may be had are limited to those that fall within the domain of science and the useful arts.

There are no doubts that new and useful machines, manufactures, and compositions of matter are subjects for patent protection, because inventions of such character clearly fall within the constitutional limitation. Machines and manufactured articles are concrete things cognizable both by the senses and the intellect. They are vendable commodities—products of the industrial arts. The doubts arise with respect to "art" or process inventions, which are abstract things, cognizable only by the intellect, although the results of such inventions may or may not be perceptible to the senses.

Judicial interpretation indicates that process inventions whose results can be apprehended only through the intellect are not patentable, while those that produce a change in the condition of matter that is perceptible to the senses may be patentable. Thus, a method of doing business, of training and educating animals, or of playing a game of cards is not patentable, while a way of making a chemical composition or a car wheel, developing power, or transmitting sounds may be patentable. The first three of the methods referred to are purely intellectual schemes producing no physical changes, while the last three effect perceptible changes in the condition of matter.

Thus, with respect to art or process inventions, arise the most fundamental doubts in the law of patents. And with respect to such inventions, even when clearly relating to the "useful arts" within the constitutional provision, the greatest uncertainty has prevailed throughout the history of patent law, both in this country and abroad. Courts, lawyers of long experience, and the Patent Office, have denied the protection of a patent to new and useful arts which were admittedly inventions. They have doubted the patentability of a process when apparatus was essential to its practice, or when no chemical reaction or "similar elemental" force took part in it.

PREJUDICE AGAINST PROCESS PATENTS.

This prejudice against and this uncertainty with respect to processes, has resulted in injury to inventors as well as to the public. It has lost to inventors the full measure of protection to which their inventions entitled them, and has rendered so uncertain a large part of the property in inventions, especially the more fundamental ones, that the interested public hesitates to manufacture and use what seems to be unprotected by patent for fear of some unexpected construction by the courts.

The phrases "mechanical process" and "function of the machine" have been disastrous to many a valuable invention. It has been enough to say that a process is merely "manipulative," involving "no chemical or other elemental action," to deny its patentability. And the description and illustration of a machine adapted to carry out a wholly new and valuable process in an application for a patent for that process, have been sufficient excuse for refusing a patent for that process on the ground that it was the mere function of the machine illustrated and described. Also, patents have been refused for new manipulative processes of making old manufactures, while, absurdly enough, claims have been allowed for the old manufactures defined by the way in which they were made. And, with equal absurdity, where claims for new processes have been refused on the ground that they were the mere function of the machines set forth for practising them, claims for the machines have been allowed in the bald terms of the several means for carrying out the successive steps of the denied process.

Assume it to have been generally perceived desirable to construct a car wheel with (1) a hard steel rim, and with (2) a soft steel hub and web, but that it was not known how it could be made and that an inventor discovers a way of making such a wheel. He applies for a patent for "a car wheel having a hard steel rim and a soft steel hub and web integral therewith," and also for the method of making it which consists in:

(1) Forming a rim portion having a circumferential groove in its inner periphery, (2) separately forming a hub and web portion in one piece of less diameter than the internal diameter of the rim, (3) centering the hub and web within the rim, and then (4) enlarging the diameter of the web by applying forging pressure thereto to thin and expand it into contact with the surface of the rim within the groove and (5) weld uniting the web and rim.

The claim for the article meets with rejection because it defines only a conception of a thing recognized in the art as desirable—a mere perception of a want, an obvious article, the problem of making which had not hitherto been solved. The process claim meets with rejection because for mechanical operations involving "no chemical or elemental action." But, in recognition that the applicant has accomplished something new, he is allowed a claim as follows:

A car wheel having (1) a hard steel rim with a grooved inner periphery, (2) a hub and web of soft steel which has been made of less diameter than the inner diameter of the rim and has been expanded into contact with the grooved portion of the rim by forging pressure and welded thereto.

It is quite obvious that this is a case of whipping the devil around the stump. The wheel continues to be merely a car wheel having a soft steel hub and web, and a hard steel rim, a patent for which was refused. The groove in the inner periphery of the rim has disappeared in the finished wheel and the web diameter is no longer less than that of the rim. The real problem before the inventor was how to make such a wheel, and the invention, if there was any, lay in the solution of that problem, i. e., in the process.

Assume, again, that one who has been making large railroad spikes in a spike machine finds that he has to heat the bar repeatedly, because of the slow operation due to the heavy duty of the machine, thus consuming a lot of time and deteriorating the quality of the metal. He observes that the metal can be shaped by rolling much more rapidly than by forging. He therefore conceives of passing the heated bar rapidly through a pair of die rolls so formed as to rough shape the bar into a string of connected spike blanks, and then immediately feeding the bar to a spike machine, which may be geared to high speed because of the light work left to be done in finishing and cutting off the blanks. Thus he finds that he can forge an entire bar into spikes at one heat. He therefore makes application for a patent for:

The process of making spikes consisting in (1) heating a bar; (2) die rolling it into a string of connected partly-formed spikes; (3) cutting off and finishing the partly-formed spikes by forging.

The specification discloses a furnace, a stand of die rolls and a spike machine arranged in tandem relation so that the heated bar may be withdrawn from the furnace and fed between the rolls and into the spike machine in a straight path. The process claim is met with a rejection on the ground that the alleged process is merely the function of the machines shown. The applicant therefore claims:

The combination of a furnace, a set of die rolls and a spike machine, and the claim is allowed. Here it seems obvious that the real invention lay in the conception of the way of making spikes. Hot metal cannot be worked with the fingers. The furnace, the die rolls, and the spike machine were all well known instruments for working metal, and any mechanic would know well what instruments to make use of upon the mere directions of the inventor *how* to make the spikes, to wit: to heat the bar, die roll it, and then finish by forging the blanks. The allowance of the combination claim in this case is clearly another example of whipping the devil around the stump.

To the simple-minded it looks as if in each of the assumed examples the inventor had not received a patent for his actual invention, and could only be protected in the practice of it by the favorable construction of the court in case the terms of the specification were such that it could be construed. And the chances are that having canceled the claims to his actual invention the patentee will not be allowed the same claim by construction, and that the thing actually claimed will be held unpatentable.

NO SOUND REASON FOR THE PREJUDICE.

It is impossible to draw from any person holding this prejudice against process inventions a sound reason for his attitude. The prevalence of it can hardly be explained except on the hypothesis of a blind inheritance of belief in erroneous premises adopted early in the history of the English law, strengthened in the minds of the case lawyers by dicta in certain decisions of our courts. That is to say, the prejudices against mechanical or manipulative processes have about the same kind of vague foundations as popular superstitions.

Our patent laws, although deriving their authority from the Constitution, yet derive their principles from the English law. In ancient times the monarch of England had a prerogative to grant monopoly patents. "The king," said Sir H. Finch, "hath a prerogative in all things that are not injurious to the subject; for in them, it must be remembered, that the king's prerogative stretcheth not to the doing of any wrong." This prerogative was in certain cases wisely exercised for the purpose of bringing into England and teaching to English subjects arts and trades of which the English people were ignorant. In the time of Elizabeth and James I. especially this prerogative was stretched to the doing of wrong by monopoly grants giving control of industries and commodities already in possession of the people. For this reason Parliament enacted the famous statute of monopolies (21 Jac. 1, c. 3) declaring that all monopolies, grants, and letters patent "heretofore made or granted, or hereafter to be made or granted.....are and shall be utterly void..... Provided also, and be it declared and enacted, that any declaration before-mentioned shall not extend to any letters patent or grants of privileges for the term of fourteen years, or under, hereafter to be made, of the sole working or making of any new manufacture within this realm, to the true and first inventor and inventors of such manufacture....."

The statute of monopolies also excepted certain named existing grants such as the so-called smalt patents, which were for processes of making a certain blue dye and the product thereof, and Dudley's patent for a process of extracting iron from its ores by the use of sea coal.

ENGLISH COURT'S OPINION ON WATT'S ALLEGED PROCESS.

In 1795 Watt's patent for a "method of lessening the consumption of steam and fuel in fire engines" came before the Court of Common Pleas. The specification set forth among other things, "My method of lessening the consumption of steam and consequently fuel, in fire engines, consists of the following principles: 1. That vessel in which the powers of steam are to be employed, to work the engine which is called the cylinder in common fire engines, and which I call the steam vessel, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first, by enclosing it in a core of wood, or any other materials that transmit heat slowly; secondly, by surrounding it with steam, or heated bodies; and thirdly, by suffering neither water nor any other substance colder than steam to enter or touch it during that time. 2. In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them; these vessels I call condensers, and while the engines are working, these condensers ought at least to be kept as cold as the air in the neighborhood of the engines, by application of water or other cold bodies." It is not necessary to quote further.

Watt's invention was the greatest of that time. The steam engine was then known and in practical use, but was inefficient. Newcomen's engine and that of the Marquis of Worcester had no provision for keeping the cylinder hot and the steam which had done its work on the piston was condensed in the cylinder by injecting cold water. The cylinder was always kept cold, therefore, and the steam rapidly condensed as soon as it was admitted to the cylinder.

Watt's primary conception of ways was that the cylinder should be kept as hot as the steam so as to prevent the loss of heat and power, and his secondary conception of ways was to withdraw it alive from the cylinder and either condense it separately or allow it to exhaust and go to waste. As means to this way of keeping the cylinder hot, he covered it with a non-conductor of heat and also provided a steam jacket for it into which he conducted live steam; and as means to his way of taking care of the exhaust, he led it into a separate condensing vessel.

Heat and methods of generating it were known at that time. The cylinder of Newcomen's engine could be kept hot by building a fire under it, thus putting into practice fully Watt's primary conception of econ-

* Machinery.

omizing steam without the use of any new means. Vessels and means to keep them cool, as well as valves and pipes for conducting fluids, were also well known at that time. So that Watt's secondary conception of ways of avoiding condensation in the cylinder could be carried out by known means.

At the trial it was persistently insisted on behalf of the patentee that the invention was a process and that it was entitled to cover under the patent any means by which the cylinder could be kept as hot as the steam and the steam condensed outside thereof. The defense urged that such contention could not be sustained, as to do so would be to sustain a patent for an abstract principle.

On the question of construction the court divided three to one, three of the judges holding the patent to be for an improvement in the construction of steam engines, while the chief justice alone held that the patent was for a process.

The majority of the judges held that the word "manufacture" in the Statute of Monopolies meant a means—a "vendible commodity"—although admitting that the term "manufactures" was commonly used to designate both the commodities made and the practice of making them. The argument seemed to take form in their minds something like this: (1) The word monopoly by derivation means an exclusive right to sell; a patent is a monopoly; therefore a patent is an exclusive right to sell. (2) Only commodities can be sold; a process is not a commodity but a principle—a mere abstract idea—therefore a process cannot be sold. (3) Conclusion—A patent can only be for a vendible commodity, and Watt's contention that his patent is for a method cannot be sustained since only vendible commodities are patentable. It must therefore be for a mechanical construction and not for a method.

CHIEF JUSTICE EYRE'S OPINION.

On the other hand, the Chief Justice in his minority opinion wrote these wise words:

"Undoubtedly, there can be no patent for a mere principle; but for a principle so far embodied and connected with corporeal substances as to be in a condition to act and to produce effects in any art, trade, mystery or manual occupation, I think there may be a patent. Now this is, in my judgment, the thing for which the patent stated in the case was granted, and this is what the specification describes, though it miscalls it a principle. It is not that the patentee has conceived an abstract notion that the consumption of steam in fire engines may be lessened, but he has discovered a practical manner of doing it, and for that practical manner of doing it he has taken his patent.

"The substance of the invention is the discovery that the condensing of the steam out of the cylinder and protecting the cylinder from the external air and keeping it hot to the degree of steam heat will lessen the consumption of steam. This is no abstract principle; it is in its very statement clothed with practical application: It points out what is to be done in order to lessen the consumption of steam. Now the specification of such a discovery seems to consist in nothing more than saying to the constructors of fire engines, 'For the future condense your steam out of the body of the cylinder instead of condensing it within it, put something round the cylinder to protect it from the external air and to preserve the heat within it.' . . . Any particular means of doing this, one should think, would hardly need to be pointed out, for it can scarcely be supposed that a workman, capable of constructing a fire engine, would not be capable of making such additions to it as should be necessary to enable him to execute that which the specification requires him to do.

"Some machinery, it is true, must be employed, but the machinery is not of the essence of the invention, but incidental to it."

The Chief Justice also pointed out that the language of the statute of monopolies defined a monopoly to be "the privilege of the sole buying, selling, making, working, or using anything within this realm," and that the statute excepts from condemnation privileges of "working or making of any new manufacture," which seemed clearly not necessarily to limit a patent monopoly to a vendible commodity.

This language of the statute received very little attention from the majority. They appear not to have considered that the royal prerogative was earliest exercised for the purpose of introducing new *trades* and "mysteries" into agricultural England, nor that the statute expressly excepted certain process patents such as those mentioned above.

Within the fifty years following the case of Boulton & Watt vs. Bull, the English courts passed many dicta, generally unfavorable to process patents. In Crane vs. Price, decided in 1842, it was finally definitely decided that a valid patent may be had for a process, without deciding that merely manipulative or mechanical processes were patentable. Even later, English law writers are found strenuously maintaining that processes, saving only chemical ones, are not patentable inventions.

No more accurate notion of the fundamental principles of the law governing the grant of patents for process inventions has been expressed than that of Chief Justice Eyre in the Watt case.

OPINION IN THE UNITED STATES ON PROCESSES.

The original United States patent act of 1790 defined the subjects of patentable inventions to be, "Any useful art, manufacture, engine, machine or device." This language is probably Jefferson's. He was thoroughly familiar with the history of monopolies and doubtless used the word "art" advisedly as the scholarly word to designate new trades, "mysteries" and industrial processes. It has persisted in successive statutes until to-day, and the courts have never had any hesitation in declaring that it means an industrial process, although they have had hesitation in declaring that all industrial processes are to be included under it.

In 1843 in the case of McClurg vs. Kingsland, the United States Supreme Court held valid a patent for " a mode of casting chilled rollers and other metallic cylinders and cones," which consisted in injecting molten metal into a mold tangentially, thereby imparting a rotary motion to it, which had the effect of concentrating the dross at the center. In 1871 in Mowry vs. Whitney, the same court sustained a patent for a process of making cast-iron car wheels which consisted in casting a wheel in a mold, removing it from the mold as soon as it had cooled sufficiently to hold its form, then subjecting it to heat to raise its temperature uniformly to a point a little below that at which it fuses, and then slowly cooling it, thus carefully annealing it in all parts. In 1876, in Cochrane vs. Deener, a process of bolting flour by passing it successively through bolting cloths of successively finer mesh and applying air currents close to the surface of the cloths to remove the finer impurities, was sustained. In 1880, in Tilghman vs. Proctor, a process patent for the manufacture of fat acids and glycerine from fats by the action of water at high temperature and pressure was sustained. Many patents have been sustained where the claim was for a chemical reaction to produce a new substance or an old substance in a new way. In 1888, Bell's patent was sustained for "the method of transmitting vocal and other sounds telegraphically by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds." In 1898, the Supreme Court, in Westinghouse vs. Boyden, said "it may still be regarded as an open question whether the patentability of processes extends beyond this class of inventions"—meaning by "this class of inventions" those "which involve chemical or similar elemental action." In 1909, the Golding patent for a method of making expanded metal lathing by slitting, stretching and bending the slitted portions into diamond-shaped meshes, was sustained by the Supreme Court after the same patent had been held invalid by the Court of Appeals of one circuit on the ground that it was for a mechanical method—the mere function of the machine used—and had been sustained by the Court of Appeals of another circuit. In this case the Supreme Court cited with apparent approval the decision of the Circuit Court in Paper Bag Co. vs. Paper Bag Co., sustaining a patent for a process of making paper bags by folding the paper in a new way, the process having been practised commercially by an automatic machine.

In 1853 the Supreme Court held invalid the claim of Morse for making intelligible signs at a distance by the use of the galvanic current, on the ground that it was a claim for a principle, and covered all possible ways of attaining the result arrived at. Since then it has invalidated many process patents as lacking invention. In 1895 it rendered a decision in the case of Risdon vs. Medart that has done more than any other ruling to unsettle confidence in process patents. That decision contained dicta from which it was widely inferred that only such processes as involved "chemical or similar elemental action" were of a patentable character. The actual point of the decision seems to have been based on the assumption that the process was the mere "function of a machine," although several machines were in fact used in making the pulley, which was the product that the process aimed to produce. Following this decision it seemed to be sufficient that a process was not of a chemical nature to deny its patentability. What the "similar elemental action" may be has never been judicially defined.

SUPREME COURT NEVER INVALIDATED CLEAR PROCESS INVENTIONS.

From the above hasty glance at a few decisions of the Supreme Court it may be deduced that neither a principle of nature, a desirable result, nor all ways of attaining a desirable result or applying a principle of nature, nor the function of a machine, are patentable subjects in their opinion. Specified ways of applying principles to secure a result, if they involve "chemical or similar elemental action," are subjects for process patents. The patentability of chemical processes has not been questioned. In one case, sustained, "similar elemental action" was centrifugal force applied to casting molten metal; in another it was the effect of heat applied so as to overcome the strains due to unequal radiation of hot metal when rapidly cooled; in another it was the application of air currents to flour in a certain way, as it was passed through bolting cloths; in another the application of electrical undulations to set up sound undulations in air; in another the mere tendency of paper to retain its folded form when folded, and in another the ductility and malleability of metal.

It is believed the United States Supreme Court has never reached a conclusion on the validity of a process patent that is at variance with the fundamental principles of lawful monopolies. They have never denied patentability to any process relating to the useful arts that involved invention, although there have been dicta from which misleading inferences can be drawn. It is difficult to reconcile a belief that manipulative or mere mechanical processes are not the subjects of a patent, in the opinion of the Supreme Court, in view of the decisions sustaining a process of bolting flour by the aid of bolting cloths and air currents, of folding paper in making paper bags, in slitting, bending and stretching metal in making metal lathing; or, in view of the same decisions, that the Supreme Court holds a process patent to be invalid where mechanism is absolutely necessary to practise it.

(To be concluded.)

CHARRON'S STUDIES OF FRICTION.

In the Comptes Rendus, F. Charron discusses the effect of a layer of air between two bodies sliding one over the other, and also treats of friction in a vacuum. When two bodies slide, one over the other, there is in general a mutual tearing out of particles of each surface, which renders the phenomenon complex. In the case of pure friction (where no tearing out of particles takes place) a phenomenon presents itself which is hidden in the ordinary case. As the relative velocity of the two surfaces increases, the coefficient of friction decreases, and becomes zero for a particular velocity which the author calls the critical velocity. This diminution of friction is due to a layer of air which interposes itself more or less between the two surfaces for velocities less than the critical velocity, and which separate them altogether for velocities equal to, or greater than, the critical velocity. Experiments were carried out with specimens of copper, brass, and graphite, sliding over a plane glass plate, which was caused to rotate in its own plane round a vertical axis. The body to be experimented on was placed on the disk and attached by two fine and flexible threads to a kind of balance, the beam of which, with the two threads, formed a triangle. Small mirrors and a divided scale allowed the displacement of the beam to be exactly determined, and from this the friction could be deduced. On increasing the velocity of rotation of the disk the displacement of the beam became less and less, the friction finally becoming so small that the threads were scarcely straightened. This small force is only due to the viscosity of the gaseous layer. The thickness of the layer could be measured by putting a source of light in the plane of the disk, and using a microscope with micrometer eyepiece. The thickness of the layer was found not to be uniform, but greater at the front than at the back. The mean value varied with the conditions of experiment, and could attain a value of several hundredths of a millimeter. With a "rubber" of graphite whose rectangular base had an area of 1 square centimeter, of weight 1.4 gramme, and loaded with different weights, the following critical velocities (which can only be regarded as a first approximation) were obtained:

Load.	Critical Velocity.
1.4 gm	192 cm. per sec.
2.4 gm	262 cm. per sec.
3.4 gm	290 cm. per sec.
6.4 gm	437 cm. per sec.
11.4 gm	770 cm. per sec.

When the apparatus was set up in a case which could be evacuated, it was found that there were notable variations of the frictional force with a pressure of only 2 or 3 centimeters of mercury. When the pressure was reduced to 1 millimeter of mercury, it was found that the coefficient of friction was sensibly independent of the velocity, thus confirming the conclusions in the first part of the paper as to the effect of the layer of air.

For the purpose of making the telephone booth really sound-proof, a German inventor lines it with tin. It seems that the lining is in every way most efficient. The result is that a German publication now advises all architects to either use tin or aluminium in the walls of houses generally to deaden sound.

MARINE VEGETATION.

SOME BEAUTIFUL SPECIMENS.

BY J. R. SCHAUER.

We still know very little about the depths of the sea. In many parts of the world the character of the sea bottom is entirely unknown and cannot even be guessed, for we know from those parts that have been thoroughly explored that the ocean covers plains, mountains, valleys, and deep chasms, the form and arrangement of which change from year to year. We know, also, that the ocean is the home of countless multitudes of vegetable and animal organisms of almost infinite variety, so that it is difficult to decide whether the sea or the land teems more abundantly with life.

The greatest known depths of the ocean are greater than the heights of the loftiest mountain peaks. Mt. Everest, in the Himalayas, and the snow-capped summits of the Andes, would disappear from view if they were dropped into the Tuscarora depression in the Pacific Ocean, east of Japan. These greatest irregularities of the earth's surface, however, are no greater, relatively, than a grain of sand adhering to a large ten-pin ball.

Both on land and in the sea, all organic life is dependent on height or depth. Life is impossible on the summits of Chimborazo and Mt. Everest, and also at a depth of five miles in the ocean, in both cases owing (partly, at least) to the absence or extreme rarity of oxygen, without which life cannot be maintained. No organism can live for any length of time either in the rarefied atmosphere of very high mountain peaks or under the enormous pressure which exists in the depths of the ocean. The most elevated dwelling places that are occupied, even during a couple of months, by human beings, are the summer camps of Tibetan goatherds in the Himalayas, where the altitude above sea level is about 17,000 feet, and the height of the barometer is 16 inches, or about half its height at the sea level. In the sea no fishes are found at depths exceeding 18,000 feet, and the limit of animal life in general is 21,000 feet. Below this level only the calcareous and silicious shells and skeletons of dead organisms are found.

The enormous pressures which exist at great depths in the ocean are strikingly illustrated by the following observations: The mouth of the dredging net employed in gathering deep-sea organisms by the "Talisman" expedition, in 1883, was held open by disks of cork as thick as a man's fist and of a diameter equal to the length of a man's hand. After the net had been lowered a number of times to a depth of 12,000 feet, the disks were less than two inches in diameter and as hard as wood. In the soundings made near St. Thomas, in the West Indies, in 1874, by the "Challenger" expedition, the glass tubes of two thermometers, about ¾ inch thick, were broken by the pressure experienced at the depth of 23,000 feet, to which they were lowered.

The greatest ocean depths that have yet been measured were found north of St. Thomas (23,235 feet), south of Nahe Island in the Aleutian group (24,311 feet), south of the Marian Islands (27,502 feet), and east of Urup Island in the Kurile group (27,946 feet). Only a small portion of the bottom of the Tuscarora basin, which has not been thoroughly explored, was reached by the last-mentioned sounding. At depths exceeding 26,000 feet the sea bottom is covered with mud, composed chiefly of the silicious shells of minute organisms.

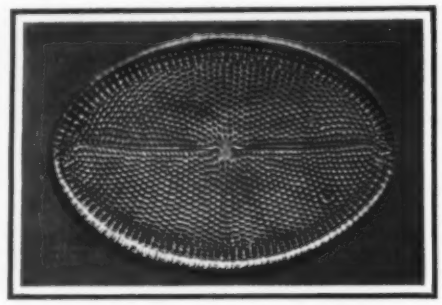


FIG. 3.—ORTHONEIS SPLENDIDA.

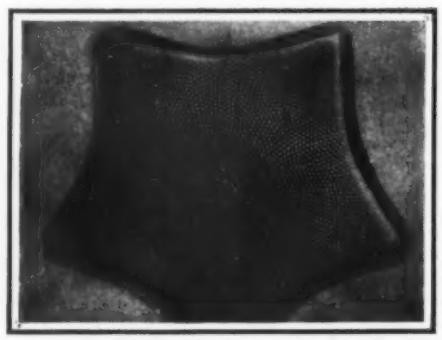


FIG. 4.—TRICERATIUM FORMOSUM.

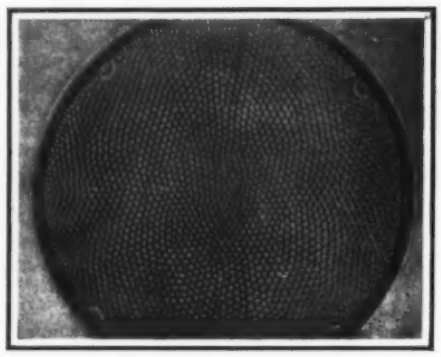


FIG. 5.—EUPODISCUS RADIATUS.

Microscopic plants, which belong to the class of algæ, and are known as diatoms, are found living in the ocean only at depths less than 200 feet, but their silicious shells are found on the sea bottom at much greater depths, down to 10,000 feet. These shells, which are so small that they cannot be seen distinctly unless greatly magnified, are very diversified in form and covered with wonderfully beautiful, regular and intricate markings, which make them admirable objects for testing the resolving power of a microscope.

One of the best known forms, still found living in the North Sea and the interior waters of northern Germany, is *Pleurosigma angulatum* (Fig. 2). The shell is long and narrow and is covered with exceedingly minute hexagonal depressions.

Orthoneis splendida, shown greatly magnified and by transmitted light in Fig. 3, is found in the Bay of Naples at a depth of about 150 feet. The flat, oval shell is thickly studded with little prominences, arranged with wonderful regularity.

Navicula practexta (Fig. 1), resembling the above, but with a somewhat different arrangement of the prominences in its central part, is found in the Gulf of Mexico at a depth of 100 feet. At a greater depth, 170 to 200 feet, in the Bay of Campeachy, occurs the beautiful species *Triceratium formosum* (Fig. 4).

Very different from all the above forms is the Californian species, *Isthmia nervosa* (Fig. 6). The shell of this remarkable diatom is in two parts, which fit into each other like the halves of a leather cigar case. The oval figure at the left of the illustration shows part of the connecting belt and diaphragm. In the same part of the Pacific Ocean, extending to the Hawaiian Islands, occurs the beautiful disk-shaped *Arachnoidiscus elegans* (Fig. 7), which is covered with delicate tracery, resembling a spider's web. The shell is composed of two flat disks and a cylindrical connecting band, like a pill box with two lids. The triangular form shown in the same illustration is a species of *Triceratium*. This shell is covered with minute facets, arranged in concentric circles. The shell of *Eupodiscus radiatus* (Fig. 5) also shows a great number of regularly arranged hexagonal facets, which resemble the "eyes" on a butterfly's wings. This species is found in the Gulf of Mexico, at a depth of 130 feet. In *Stictodiscus tuberculata* (Fig. 10), the two halves of the shell are not flat, but concave, and are covered with larger excrescences, arranged radially. This species is extinct, but its shells are found in the marl beds of St. Monica, California. The shells of still another disk-shaped diatom, *Arachnoidiscus Ehrenbergii* (Fig. 11) cover parts of the California coast to a depth of several inches. This species is characterized by heavy radial ribs intersecting a very delicate spider-web pattern.

The singularly formed *Navicula pandura* (Fig. 9) is found in the Bay of Genoa at depths between 100 and

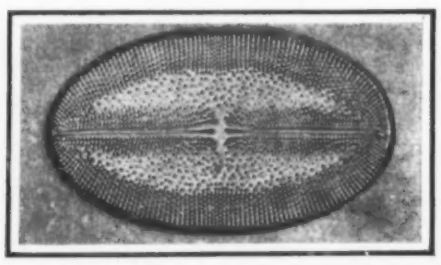


FIG. 1.—NAVICULA PRAETEXTA.

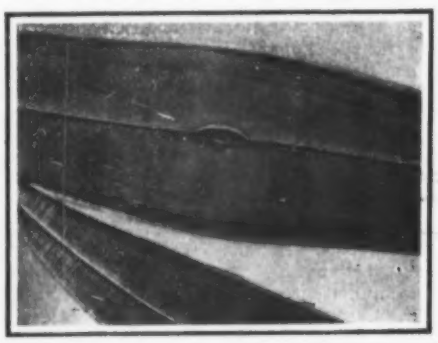


FIG. 2.—PLEUROSIGMA ANGULATUM.

FIG. 6.—ISTHMIA NERVOSA.

FIG. 7.—ARACHNOIDISCUS ELEGANS.

160 feet. Its shell is marked by a series of parallel corrugations intersected at right angles by a heavier ridge and two deep furrows. Similar in marking, but much smaller and of oval form, is the allied species, *Navicula Hennedgi* (Fig. 8), which is found off the coast of New Zealand. Hundreds of other examples could be shown to illustrate the marvelous beauty and variety of these minute organisms.

From time immemorial the natives of certain districts of Liberia, northern Africa, South America, the West Indies, and other parts of the world have mixed peculiar local varieties of earth with the meal of which their bread was made. Specimens of the earth thus used were brought to Europe by explorers, and examined by Ehrenberg, who proved that they were composed entirely of the shells of diatoms. This "mountain meal" is still eaten in Sweden and Lapland. Diatoms multiply with amazing rapidity, a single individual producing nearly nine million descendants in four weeks. In various parts of the world are found beds of kieselgur, or "infusorial earth," tripoli, and marl, from 6 to 150 feet thick and hundreds of square miles in area. These substances consist almost entirely of diatom shells. According to Ehrenberg's estimate, one cubic inch of Bohemian tripoli contains more than forty thousand million shells of the diatom *Gallionella distans.*

Part of the city of Berlin rests on a bed of kieselgur 100 feet in thickness. Living diatoms are found in a stratum of kieselgur, more than 30 feet thick, in the Lueneburg Moor.

Dynamite consists of kieselgur mixed with nitroglycerine, and guano is composed largely of the shells of diatoms which birds, feeding on the seacoast, have swallowed with their food. Each variety of guano contains characteristic species of diatoms.

The masses of ice which drift northward from the South Pole are often found covered with a brown layer of marine diatoms. It is conjectured that the Antarctic continent is covered with diatomaceous earth. In a similar way, when the natural habitat of a particular species of diatom has been definitely located, important geographical and geological conclu-

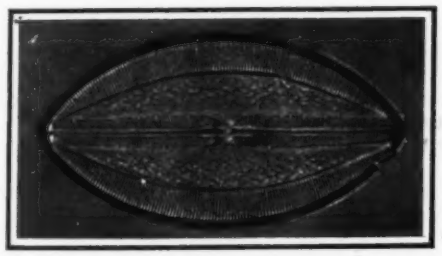


FIG. 8.—NAVICULA HENNEDGI.

sions may be based on the occurrence of that species, as revealed by the microscope, in other places.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Illustrirte Zeitung.

THE USE OF NATIONAL FORESTS FOR RECREATION.

BEFORE the year's outing season is over nearly half a million persons will have sought recreation and health in the national forests of the United States. According to the records of the United State Department of Agriculture, the total last year was, in close figures, 406,775. With the finest mountain scenery and much of the best fishing and big-game hunting in the United States, the national forests, made more and more accessible each year through protection and development by the government, are fast becoming great national playgrounds for the people.

The use of the forests for recreation is as yet in its beginning, but is growing steadily and rapidly—in some of the forests at the rate of a hundred per cent per annum. The day seems not far distant when a million persons will annually visit them.

The records show that the seasonal use of the forests runs from two months in a Colorado forest, such as the Routt, to twelve months in an Alaskan, such as the Tongass. But the uses differ. In Colorado the 2,000 visitors entered the forest to fish, to camp, to climb, and to drink the medicinal waters; in Alaska the 1,000 almost solely to hunt and fish. The 21,000 persons who went into the Coconino forest, Arizona, during nine months went to camp or to enjoy the scenery. During four months 50,000 persons visited the Angeles, California. The most popular of the forests is the Pike, containing the famous peak of that name. The various attractions within its limits, including the scenic railway, drew 100,000 tourists and others. By principal States the national forest visitors numbered 23,000 in Arizona, 103,000 in California, 140,000 in Colorado, 19,000 in Montana, 10,000 in New Mexico, 33,000 in Oregon, 22,000 in Idaho, 16,000 in Utah, and 12,000 in Washington.

Of the natural wonders and landmarks of interest in the national forests several have been set apart as national monuments, among them Cinder Cone, a great lava basin in California; the Gila Cliff Dwellings, extensive remains of a prehistoric race in New Mexico; the unsurpassed Grand Canyon of the Colorado in Arizona; Jewel Cave, South Dakota; Lassen Peak, the terminus of a long line of extinct volcanoes in the Cascades; the Pinnacles, a collection of remarkable jagged peaks in California; and the Tonto, a group of prehistoric ruins in the Tonto forest in Arizona. The Big Trees, Glacier Park, the Petrified forest, the Oregon Caves, and numerous other phenomena serve to attract other hosts of visitors.

The sportsman finds his paradise in the national

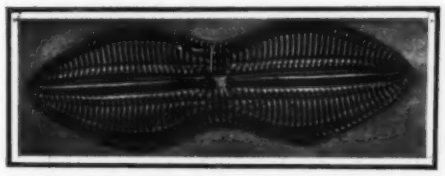


FIG. 9.—NAVICULA PANDURA.

forests. In many of them big game abounds. The rangers and the guards, besides the service they perform against the spread of fire, often point out the best site for the camper and the easiest route. A record of 9,218 miles of trail cut, 1,236 miles of road laid out, and 4,851 miles of telephone line strung, tells what the government has done in the way of pushing the conveniences of civilization into the primeval forest. The day of the wilderness of the savage and the pioneer is swiftly passing; the day of the national forests as productive resources and as national parks approaches with rapid transformation.

THE SUN-BURNT FACE.

RIGHTLY or wrongly, the face browned by the sun is regarded as an index of health, and there are some persons who feel that the money spent upon a holiday has been well spent if they come back sun-burnt. This view is in general justifiable, since the sun-burnt face implies that the individual has been exposed to a fresh, healthy, and open environment—to surroundings, that is to say, which have reacted upon him in a way which routine fails to do. It is true that nowadays the mere pigmentary effect of the sun upon the skin can be readily imitated by employing the chemical or ultra-violet rays of the electric light, and in particular the rays of the quartz mercury lamp; and so, if all the result required of a holiday was merely a sun-burnt face, this could be done in the space of minutes instead of an expensive holiday at the seaside extended over weeks. It follows that mere sunburn is not, strictly speaking, an index of acquired health. No amount of ultra-violet ray treatment, however, can produce the decided general improvement in health and tone which a change of air and scenery does. The truth is that the sun's rays are only one contributory factor to the restoration of health, and therefore the sun-burnt face is merely evidence that the opportunity of an outdoor life has been seized. But the outdoor life connotes constant fresh air and exercise, in the wake of which follow healthy functional activity, good nutrition, and a general equilibrium of the system, all of which means that the machine is going smoothly, and that the life processes are not hampered by excess or by shortage. These

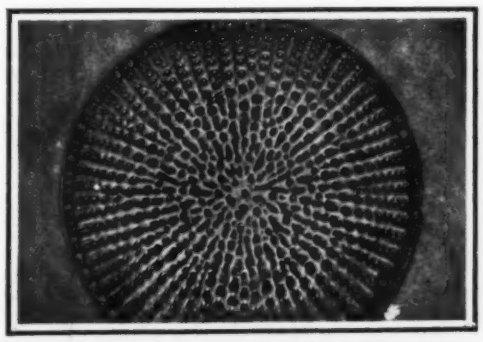


FIG. 10.—STICTODISCUS TUBERCULATA.

conditions apart, it is probable that the bronzing produced by exposure to the sun is to some extent an indication of vigor and a satisfactory state of the blood, since the hemoglobin of the blood supplies the pigment to a sun-burnt skin and in this way serves to protect the tissues. If this protection is not afforded, blistering or sun eczema may result. In a word, sunburn is merely a protective effort of the body. The active light rays of the sun, again, undoubtedly give a healthy stimulus to the respiratory process, since under their influence it has been proved that the quantity of oxygen absorbed is greater, while an increasing output of carbonic acid follows. It is interesting to recall in this connection the experiment which showed the apparent anomaly that animals deprived of nourishment die sooner in the chemically active rays of the sun than when they are exposed to the inactive rays. The activity of the vital processes in these cases being augmented, the store of energy was soon used up. Exposure to sunlight, again, increases the number of blood cells, but the absence of light diminishes the number. A face burnt brown by the sun would seem, regarded in this way, to be a sensible object of a holiday, not, however, because the face is so bronzed, but because the circumstances which conspired to produce the brown complexion have other factors favorable to an all-round healthy state.—The Lancet.

THE MAGNETISM OF SOLUTIONS.

P. DRAPIER has considered the magnetism of solutions. The solutions examined were placed in a thin vertical cell in the air-gap of a powerful electromagnet. Paramagnetic liquids, tending to move radially in a plane normal to the lines of force, develop a convexity at the surface, which is increased when the surface tension (of aqueous solutions) is lowered by addition of ether or benzene. A 1 per cent aqueous solution of ferric alum or ferric chloride shows a convexity even, but a solution of the same concentration in ether is unaffected. Ferric ammonium oxalate is but slightly affected, and colloidal ferric hydroxide, potassium ferrocyanide, and potassium ferricyanide are unaffected. If a solution of ferric chloride in ether is floated on water a striated layer is produced, which, in the field, bends downward into the water, the striæ being displaced horizonally. Dilute manganese sulphate gives a marked convexity, but potassium permanganate none. Cobalt and nickel hydroxides precipitated by ammonia are also very sensitive to the magnetic field. Chromium sulphate, cobaltous chloride, and nickel nitrate are paramagnetic; potassium dichro-

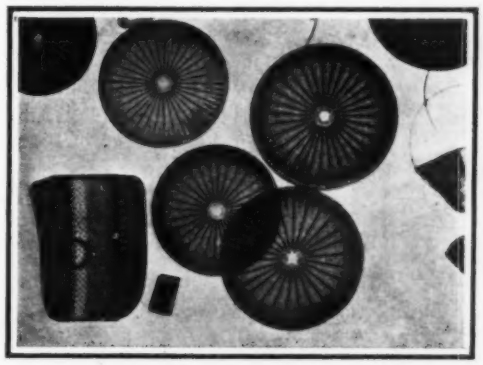


FIG. 11.—ARACHNOIDISCUS EHRENBERGII.

mate, potassium cobalticyanide, titaninum sulphate, and platinum chloride are not. Drapier's observations confirm Pascal's conclusion that as a magnetic metal becomes more and more removed from its normal (ionized) state it loses its paramagnetism. The magnetic capillary rise of 5, 7½, and 10 per cent solutions of ferric alum and ferric chloride was investigated. On increasing and decreasing the exciting currents between 0 and 10 amps. marked hysteresis was found in the capillary rise, apart from the usual hysteresis of the magnet. This effect is thought by Drapier to be true liquid hysteresis.

Experiments with the carbon filament of an ordinary incandescent lamp, made by E. Bruné, show that when the filament is heated to an orange-red color it attracts a negatively charged body; that as the temperature is further raised it passes through a state when there is no sign of electrification; and that at a white heat it attracts a positively charged body. This inversion of sign is not dependent only on the temperature. Using a Pt filament inclosed in a glass tube connected with a mercury pump, Brunè has verified that at the ordinary pressure, raising the temperature rapidly from red heat to the maximum heat attainable with Pt-wire increases the emission of positive ions; under slightly reduced pressure, on the other hand, there is a diminution of electric charge, and as the pressure is further reduced, inversion of the sign of electrification takes place, and finally there is a preponderance of electrons. These phenomena may be explained by assuming that a gas adheres to, or is occluded by, the filaments, and being liberated when the filament is heated, its particles come in contact with electrons emitted by the incandescent filaments, thus giving rise to positive ions. As the temperature rises this gas expands, the increase of pressure causing the inversion of electric sign. Further experiments will be conducted to determine whether the phenomena are independent of the nature of the filament itself, or in what way they depend upon it.

THE MEDIUM OF CELESTIAL SPACE.

RECENT ASTRONOMICAL ADVANCES.

The physicist knows well that the problems with which he has to deal are insignificant, or at best subsidiary, says Nature, when compared with the great questions so intimately connected, What is matter? and What is æther? The astronomer, though he observes the operations of nature on a vaster scale, deals with problems of a less ultimate character. Thus, when he seeks to investigate the properties of that medium in which the solar system and the stars alike are moving, he is far removed from any metaphysical abstraction, and only seeks the answer to perfectly definite, concrete questions concerning the transparency and dispersive qualities of the medium. But if the questions are concrete, they are by no means simple, and though the last two years have seen a simultaneous attack on the problem on several converging lines, the main result has been to make us realize the immense difficulties which lie in the way of a definite conclusion.

Whether there is a general absorption of light in space, from whatever cause arising, is a point which suggests itself most obviously. Without attributing any absorptive power to the æther itself, it is easy to see reason for inferring that a loss of light does take place. The streams of meteors which enter our atmosphere have not always been within the sphere of influence of the solar system, but have probably come in incalculable numbers from outer space. There is a continual drain on the atmospheres of the sun and planets owing to the loss of the fastest-moving molecules. The empty spaces which have been found to exist in the midst of the densest star clouds, and the curious rifts which interrupt the continuity of certain bright nebulæ, suggest the presence of obstructing nebulous masses such as that which was only revealed by the outburst of Nova Persei. It is thus reasonable to suppose that a sensible amount of absorbing matter exists in space. But to form a quantitative estimate of its effect is a task of which our increased knowledge makes us only the more appreciate the difficulty.

The problem would be simpler if we could accept the conditions supposed by the earlier astronomers. For them the extent of the universe was indefinitely large, and the distribuption of the stars roughly uniform. Moreover, they imagined that the intrinsic brightness of all stars was nearly constant, and that the observed differences of magnitude were almost entirely attributable to the effect of varying distance. But for an effective general absorption we ought, in these circumstances, to expect the whole sky to shine with the average brilliance of a stellar surface, and Halley, in supposing otherwise, was guilty of a simple error. The truth of this was perceived by Cheseaux (1744), and later by Olbers (1823), and both astronomers inferred an extinction of light in space without estimating its amount, or even supporting it by direct evidence, rather than admit that the universe was finite. The first estimate based on these premises was given by W. Struve in his "Etudes d'Astronomie Stellaire" (1847), a work of great historical interest. Using the data provided by Herschel's gages, and the counts of Bessel and Argelander, Struve concluded that light coming from the mean distance of sixth-magnitude stars suffered a loss of 8 per cent of its intensity. But we have ceased to regard as valid the premises on which this conclusion was based. We know now that the variability of the intrinsic light of the stars is so great that distance can no longer be considered as the chief factor in determining their apparent magnitudes. There are also grave difficulties in the way of assuming that the universe extends with finite density to an infinite distance. Seeliger has pointed out that unless the Newtonian law of gravitation be modified, an infinite strain will exist at every point; and even if the smallness of the total light of the sky be accounted for by some kind of absorption, a thermal difficulty remains; for any part of an infinite and eternal universe will be, as it were, within an isothermal inclosure, and the temperature at every point will be at least 6,000 deg. C. (10,832 deg. F.). Such considerations, and the facts of observation, have led us to abandon the idea of an infinite universe, and Newcomb asserted, not only that the system of the stars was finite, but that there was no evidence that any extinction of light in space occurred. That will not hinder us from seeking for evidence. If we possessed a knowledge of the spatial relations and the luminosities of the stars, if, in a word, we held the key to the sidereal problem, we should be in a position to assess the absorption of light in space. But without assessing the loss of light according to distance, the sidereal problem cannot be solved. In fact, the two problems are interdependent, and it may be long before a satisfactory solution is reached.

There is, however, a subsidiary line of attack possible. The absorption may be selective in its character, or, in other words, its amount may be a function of the wave-length. This will be the case if it is due to scattering by particles the dimensions of which are of the order of a wave-length of light. It is not absolutely clear that a similar effect may not be produced by the æther itself. In either case a corresponding dispersion is to be expected, and the rate of propagation will depend on the color of the light. If any celestial phenomenon be carefully observed which is strictly localized in space and in time, the relative rate of transmission for different parts of the spectrum can be detected. Newton approached the subject from this point of view, and suggested the eclipses of Jupiter's satellites as suitable phenomena for investigation. It is well understood now that the conditions of a gradual eclipse are quite unfavorable for the detection of subtle color changes, and the distance in this case is altogether too small. The circumstances of stellar aberration have also been invoked to set a limit to the possible dispersion. But the sensitiveness of this test is also too small, for a difference of as much as one-half per cent in the rate of transmission would at best produce a spectrum of 0.1 inch in length (and this is about the estimated width of the fine micrometer wire of the largest refractors). As nothing of this order is to be looked for, a finer test must be sought. Arago conceived the possibility of detecting a change of color in variable stars according to the light phase. Contenting himself with the simple inspection of certain variables, he concluded that there was no such effect. As a matter of fact, more careful observers have noticed a change of tint accompanying the change of brightness; but even so the natural explanation is to be found in the physical character of the stars. This illustrates the need for a cautious interpretation of results, as well as for the most careful and refined methods of observation.

A great advance in practical methods has been made recently by M. Nordmann, of Paris. His plan has been to study the light curves of certain variable stars, using the light from different regions of their spectra, in accordance with the belief that a sensible dispersion in space must produce a want of simultaneity in the respective curves. With this object in view he designed an ingenious modification of the Zöllner type of photometer. By its means the light of the star examined can be compared with an artificial star produced by condensing on a small hole the light of an Osram lamp fed by a constant current. Before entering the eyepiece, the light from both images passes through one of three liquid light filters, and thus the comparison is made in red, green, or blue light as desired. Whatever opinion may be formed of the validity of M. Nordmann's conclusions, it is fair to say that his apparatus has been admirably designed, and that much is to be expected from the systematic application of his method to the study of colored and variable stars. Finding the atmosphere of Paris unsuitable for delicate researches of this kind, he took his apparatus to Biskra, in Algeria, where he spent several months in 1907-8. Unfortunately, the climate of this station did not fulfill expectations, owing to the prevalence of sand storms, and this fact may account for a certain want of continuity in the observations in a research which demanded continuity as a necessary condition of complete success.

M. Nordmann studied chiefly the stars β Persei and λ Tauri. But before alluding to his results, we may refer to the nearly contemporaneous work of M. Tikhoff, of Pulkowa. M. Tikhoff has conceived more than one ingenious method for attacking the problem of dispersion in space. One of these is in principle the same as that of M. Nordmann, but differs from it in employing photography instead of direct visual estimates. By using bathed plates, the region of the star examined is photographed through certain screens, which are prepared in such a way as to allow only light belonging to restricted ranges in the spectrum to be effective. Thus, an orange screen may be expected to give results comparable with those obtained by visual methods, while a blue screen will give photometric estimates in the ordinary photographic region of the spectrum. By this method M. Tikhoff studied the variables RT Persei and W Ursæ Majoris. Some years previously he had compared the velocity curves and the light curves of the stars δ Cephei and η Aquilæ, which are well-known spectroscopic binaries and variable stars. Inasmuch as an accepted theory of the physical nature of stars of this type is still wanting, this method must be considered radically unsound. But more recently M. Tikhoff has had the happier idea of comparing the velocity curves as determined from lines in separate regions of the spectrum. Theoretically, this would seem to be the method of all those which have been suggested which is the most free from objection. But it is doubtful whether, among the spectrographic observations already made, even of the highest class, suitable material exists for the successful application of the method. It is certainly possible to criticise on definite and practical grounds MM. Tikhoff and Belopolsky's discussion of the case of β Aurigæ.

The results already obtained may be tabulated thus:

Star.	Range $\mu\mu$	Lag. min.	Authority.
β Persei	680-450	13	Nordmann
λ Tauri	680-450	30	Nordmann
RT Persei	560-430	4	Tikhoff
W Ursæ Majoris	625-380	10	Tikhoff
β Aurigæ	450-400	10-20	Tikhoff

The third column, which alone requires explanation, contains the retardation, expressed in minutes, of some event observed in blue light over what is supposed to be the same event observed in light of greater wave-length. The event in the first four cases is the light minimum of the star, while in the fifth case it is the disappearance of the radial component of the velocity relative to the sun. Unfortunately, we have no trustworthy determinations of the parallaxes of these stars. Pritchard's values for β Persei and β Aurigæ are near 0.06 second, and M. Tikhoff himself has found the parallax of RT Persei to be insensible. Thus we can only note the qualitative agreement in the sign of the lag in all cases, which suggests that blue light is transmitted through space at a lower rate than light of longer wave-length. Yet the results are liable, even on this ground, to serious criticism, which has been expressed forcibly by Prof. Lebedew. It is not surprising that close inspection shows that the data in the case of β Aurigæ are not self-consistent. But in the other cases we cannot be certain that the observed event is really synchronous in its origin for different qualities of light. This essential condition may be nullified by the physical character of the star, as, for instance, by a selectively absorbing atmosphere of the occulting body. Prof. Lebedew is entirely right in suggesting these criticisms, but they do not prove that the medium filling space is without dispersive power; and even if this fundamental question is left open, it is to be hoped that researches will be continued on the same lines, for the ingenious methods of MM. Nordmann and Tikhoff bid fair to extend our knowledge of variable stars in a most helpful way.

Meanwhile the line of direct investigation of a possible selective absorption in space has been followed. If two stars the intensities of which are I_1 and I_2 require exposure times T_1 and T_2 in order to register images of equal density on a photographic plate, we may put (after Schwarzschild)

$$I_1 T_1^p = I_2 T_2^p.$$

A priori we might expect the same effect to be produced by the same incident energy, or $p = 1$. As a matter of fact, a number of independent researches have suggested that p is much nearer the value 0.8. This deficiency in the value of p has been attributed to the properties of the photographic plate. But it occurred to Prof. Turner that the fact might have its origin in cosmic causes. He had deduced from the Greenwich astrographic results that "when the time of exposure is prolonged in the ratio of five magnitudes, the photographic gain is four magnitudes." This result, which has been reached by others in more or less the same form, is equivalent to the above statement that $p = 0.8$. A number of facts connected with visual and photographic magnitudes could thus be reconciled by supposing that the small particles distributed in space actually produced a selective scattering in accordance with Lord Rayleigh's law.

It seemed as if a crucial test was at hand to try this hypothesis. It was only necessary for M. Tikhoff to apply his light-filters and to see whether the apparent law of photographic action was the same for the blue starlight which affects the ordinary plate, and for the visual rays to which the bathed plate is sensitive. The experiment was immediately made, and the first results seemed to bring a striking confirmation to the hypothesis. M. Tikhoff found that $p = 0.67$ to 0.79 for the photographic rays, but that $p = 0.91$ to 0.96 for the green-yellow rays. But Mr. Parkhurst, of the Yerkes Observatory, who has made a special study of the subject of photographic photometry, strikes a note of warning. Under conditions apparently similar, he has obtained $p = 0.88$ for the ordinary plate, and $p = 0.81$ for the bathed plate with color-filter. These results go in the opposite direction and must be attributed to the different plates (Schleussner and Cramer) and filters employed. Mr. Parkhurst concludes that "if cos-

mical causes played any part in the matter they would be completely masked by photographic effects."

The inter-relation which has been noticed between the problem of absorption in space and the problem of sidereal structure has naturally engaged the attention of Prof. Kapteyn, who has been the most prominent and assiduous student of the latter question during recent years. He has noticed that the marked deficiency in the numbers of the fainter classes of stars is equally apparent in all directions of the sky. Unless this peculiarity is attributable to the effect of general absorption, we must suppose that the sun is situated at the center of the universe, and though such a thing is perfectly possible, it is not specially probable. Kapteyn prefers to admit an absorption of light, and provisionally estimated the loss required by the hypothesis of nearly constant star-density as 0.016 of a magnitude for stars with a parallax of 0.1 second. More recently he has brought forward an interesting argument of a qualitative kind. Miss Cannon's classification of star spectra distinguishes between two classes which differ only in showing greater or less relative absorption in the violet end of the spectrum. Arcturus is the type of the stars less affected, while α Cassiopeiæ is the type of those more affected in this way. If the property is not intrinsic in the stars themselves, stars belonging to the Arcturus class should be nearer to us than stars like α Cassiopeiæ. Hence the former class should, on the average, possess greater proper motions. Put to the test, 45 stars of the α Cassiopeiæ division gave an average centennial proper motion 11.4 seconds, and 25 stars of the α Bootis division gave 47.1 seconds. Thus the idea is confirmed that the distinction is due to absorption in space. A number of interesting points are involved in this line of argument, and it is to be hoped that it will be further tested by extending its area of application.

Quite lately Prof. Kapteyn has published a second and more extended research on the subject. In this he investigates the amount of selective absorption, and starts from the principle that "the phenomenon must manifest itself in this, that, *ceteris paribus*, the more distant stars will be redder than the nearer ones." As a measure of redness he employs the difference, photographic *minus* visual magnitude, derived from the Draper catalogue and the Harvard revision. It would be profitless to use direct determinations of parallax, for the material at hand is far too scanty and untrustworthy. Hence he derives the measures of distance from his own statistical discussions, which have enabled him to express the average parallax of a star as a function of its magnitude and proper motion. The necessary data have thus been found for 1,433 stars, and separate equations have been formed for the different spectral classes and certain ranges of proper motion within each class. It is impossible here to follow the rather complicated discussion in detail, but the result obtained on certain simple assumptions as to the nature of the scattering of light implies a loss of

0.00867 of total light = 0.00945 of mag. for photographic rays

0.00427 of total light = 0.00465 of mag. for visual rays

in the case of a star the parallax of which is 0.1 second, or the distance of which is 32.6 light-years. Kapteyn considers that these numbers represent lower limits, and finds no difference between galactic and extra-galactic regions of the sky so far as selective absorption is concerned.

Despite the contradictory nature of the evidence, it must be felt that the whole subject is full of interest. It is now receiving the most critical and exhaustive discussion, and the need for fresh material will stimulate original and appropriate observations. It is pleasant to learn from Prof. Kapteyn that the plan of work for the 60-inch reflector on Mount Wilson includes special provision for this line of study. Efforts directed with a serious purpose and pursued with sincerity do not go unrewarded.

DIESEL OIL ENGINES.

RECENT DEVELOPMENTS.

ALTHOUGH Diesel engines have been in satisfactory operation in this country for a number of years, it cannot be said, claims the London Times, that their qualities are fully realized by the majority of engineers, even by those who are responsible for the installation of new plant under conditions when they could be advantageously employed. It is not generally known that there is in London a power station with an output of several thousand horse-power in which Diesel engines alone are installed, and those unaware of this fact might receive with incredulity the idea of so equipping a station of this size, though it has been found after a considerable period of successful work that results have been obtained which compare very favorably with the most modern steam turbine generating stations. The manufacture of Diesel engines is now being taken up in England by several well-known engine builders, and though for a large engine it is still necessary to go abroad, this is a point which time will assuredly remedy.

Up to about two or three years ago all Diesel engines were of the four-stroke cycle, the first stroke being the suction, the second the air compression, the third the ignition and expansion, and the fourth the delivery to exhaust. The large majority of engines are still of this type, but for larger powers and in cases where it is important that the weight should be reduced, engines working on the two-stroke cycle are now manufactured, and run with entire satisfaction, giving rather less than twice the output for otherwise similar designs. These engines have a slightly higher fuel consumption than the four-stroke machines, and cost approximately the same per horse-power, so that it is only in special circumstances that they are employed.

The speed of four-stroke Diesel engines is usually between 160 and 200 r.p.m., and the weight per brake horse-power being necessarily high, it was natural that an attempt should be made to construct a smaller and lighter machine by increasing the speed. Great success has been attained in this direction, and engines are made to run at 300 to 400 r.p.m. for all powers. It may be mentioned that a standard type of 300 horse-power two-stroke machine with four cylinders, designed for a speed of 400 r.p.m., has a weight of only 70 pounds to 80 pounds per brake horse-power, and is in many ways better adapted for driving electric generators than the four-stroke type. A much smaller fly-wheel may be employed for a given cyclic variation, and the dynamo is much smaller and lighter, while the fuel consumption is only 5 or 6 per cent higher than with the ordinary engine. There is, moreover, a considerable reduction in the height, which is of great importance when the engine has to be installed in a confined space, as is frequently the case when, for instance, the plant is used for supplying current to large buildings and is placed in the basement. Forced lubrication is employed, with oil at a pressure of 50 pounds per square inch and over, and the engine is totally inclosed. This type of machine has for some years been employed in British battleships for driving dynamos supplying current for auxiliary purposes, and it is probable that Diesel engines of this design will have extensive use at sea on the larger ships in the future. The cost of fuel and attendance is very much less than with steam engines, the engines may be started up at a moment's notice, and may be run in port without having to keep a donkey boiler going, as is now necessary with steam-driven sets.

In the early days of the Diesel engines the largest size built was limited to about 80 horse-power per cylinder, and hence, as with gas engines, machines of large output were impracticable. No difficulty is experienced at the present time in constructing engines with cylinders of a very much larger power, 200 horse-power per cylinder being quite common, and in the near future almost any size seems likely to be available.

Messrs. Carels, of Ghent, are manufacturing at the present time a single-cylinder 1,000 horse-power engine of the two-stroke type, while the Maschinenfabrik Augsburg Nürnburg is making a 10,000 horse-power machine with only four cylinders, this being, of course, also of the two-stroke type. This firm is also making trials on a Diesel single cylinder horizontal engine of 150 to 200 horse-power, specially constructed to use the very worst kinds of oils. The only feature which calls for comment in this machine is the fuel injection apparatus, two nozzles being fitted —one for good fuel and one for bad fuel.

Having proved by long experience that the Diesel engine is a most satisfactory motor for all purposes on land, nearly all the manufacturers of this type of machine are making strenuous efforts to adapt it to marine propulsion. Small tugs and launches have frequently been fitted with Diesel engines, but nothing on a large scale has yet been done, at any rate with direct drive. There is, however, a boat in commission in Russia in which ordinary Diesel engines drive the shafting through a clutch, and also an electric generator which supplies power to motors on the propeller shaft, the arrangement being that for reversing and for running at low speeds the engines drive only the dynamos, while the propeller shafts are operated by the electric motors; for high speed (anything above one-half full speed) the clutch is put in and the engines drive direct.

One of the large Continental firms has constructed a four-cylinder 1,000 horse-power two-stroke reversing engine, which has now been running in their works for some time, and a second similar machine is being built, to be installed in a twin-screw cargo boat. The normal full speed is 220 r.p.m., and at 250 revolutions a power of 1,150 horse-power is developed, while by throttling the oil supply any speed above 40 r.p.m. may be obtained. A fifth cylinder is provided for scavenging out the remanent exhaust gases, and the reversing is accomplished by reversing the cams by means of a lever. The fuel consumption is naturally somewhat higher than with the ordinary type, and is reckoned to be something approaching 20 per cent in excess.

Perhaps the most important step yet taken regarding the employment of Diesel engines for ship propulsion is that of the Hamburg American Company in actually placing an order with Messrs. Blohm & Voss, of Hamburg, for a 9,000-ton liner for the Atlantic service, which is to be equipped solely with Diesel engines. There will be two engines each of about 1,500 brake horse-power, the propeller speed being about 150 r.p.m. for the full vessel speed of 12½ knots. The speed of revolution is rather high, and probably there will be some loss in the propulsive efficiency as compared with a reciprocating steam installation for the same boat, but the economy of the oil engines is so far in advance of the steam plant that this loss will be almost negligible. As a similar boat is to be built at the same time with an ordinary steam engine equipment, competitive trials will be possible and should provide some very valuable data.

It is to be anticipated that further developments will take place in England regarding the use of Diesel engines for marine work. There is at the present time a launch in service on the Thames fitted with a reversing Diesel engine, working with perfect satisfaction, though of course it is of relatively small power; and moreover one of the largest firms who have taken up the manufacture of these engines is now experimenting with a reversing type of which it is expected the Admiralty will make extended trials. This engine has been running at the maker's works for some time and probably will shortly be put into commission. There is so much to gain in economy by employing Diesel engines for ship propulsion that, should the direct drive be found unsatisfactory, there is considerable likelihood of a purely electro-mechanical system coming to the fore, which for other reasons possesses many advantages. There would of course be some loss in transmission of power, but on the other hand engines of the ordinary land type would be used, with a higher efficiency than can ever be attained by the reversing machines, and in any case the superiority over the present steam engine drive would be large, since the same power could be developed with about one quarter the weight of fuel.

Among the other fields in which the Diesel engine may yet find great scope is that of locomotive engineering, and it is interesting to note that the largest German builders of these engines have a locomotive so equipped now in their works. It is to be admitted that one can hardly be very sanguine about the prospects in this direction, but none of the difficulties experienced is insurmountable and a considerable measure of success may be expected in the future. In a way the Diesel engine is as remarkable an invention as the steam turbine, and while the progress of the latter seems to have reached a limit, the possibilities of the former are now being more generally recognized, and its application during the next few years may bring about some far-reaching changes in many branches of engineering.

Sacks of earth to be used in building bag cofferdams should, as is often stated, be only partially filled. Otherwise they will be well rounded and leave large crevices, which are difficult to close. Failure to observe this resulted in considerable extra labor cost in recent repair work on a water-power tailrace in Indiana. This cofferdam, moreover, extended across the stream, and was built out from both banks. As a result, the flow was concentrated in the center of the stream, and sacks were washed away when the closure was attempted. Mr. James Wilson, in an article in the Electrical World, suggests that such cofferdams should be built from one bank. The closure is then made on the opposite bank, where the water is shallow and the current is probably less swift.

ENGINEERING NOTES.

A reversible De Laval turbine has been devised by G. De Laval and E. Fagerstrom. It consists of a vaned wheel which carries two concentric sets of oppositely curved vanes. Steam is conducted to these vanes through passages provided between concentric conical shells with helices in these spaces so as to form sets of nozzles discharging the steam against the vanes for either "forward" or "astern" direction. These conical passages receive steam from annular chambers, into either of which it is admitted at will by means of a hollow conical-plug-shaped steam valve, having suitable ports cut in its sides. An exhaust chamber is provided, and the gearing and shafts, etc., are those usually employed with De Laval turbines.

The statistical summary of vessels totally lost, broken up, condemned, etc., now published by Lloyd's Register shows that during 1909 the gross reduction in the effective mercantile marine of the world amounted to 866 vessels of 939,232 tons, excluding all vessels of less than 100 tons. Of this total 383 vessels of 645,670 tons were steamers, and 483 of 293,562 tons were sailing vessels. These figures exceed those for 1908 by 129,940 tons—steam 79,183 tons, and sail 50,757 tons. This excess is not due to actual casualties, the figures for which show a diminution of 31,471 tons, but entirely to the unusual number of vessels which have been broken up, dismantled, etc. The amount of tonnage so dealt with during 1909 exceeds by far the figures reported in the Society's Wreck Returns for any year, being 121,383 tons more than the total for 1907, which was the highest previously recorded.

The Town Council of Hamilton recently made inquiry into the system of hydraulic stowing of coal wastes which has been for some time successfully operated on the Continent. The mode of operation is to excavate the coal in the usual way and to support the roof with timber until a certain area is worked, when the whole of the excavation is filled with débris, which is conveyed by water from the surface finished into the excavated area under pressure. The area to be stowed is screened off so as to allow the water to escape, while the débris is retained, filling up the excavation and lessening the subsidence of the surface. It is not known whether this system can be successfully applied in Lanarkshire, but tests will shortly be made by the Wishaw Coal Company, who are laying down the necessary plant at Baron's Haugh, on the estate of Lord Hamilton of Dalzell. The system is expected to be in operation in a few months. This will be the first occasion on which the system has been tried in Britain.

A piece of work recently carried out at Hamburg Germany, shows that masonry construction can be very well repaired by injecting cement. The operation was carried out upon the stone arches of two parallel bridges which take the railroad tracks across the middle and south canals. Here the span of the arches is 51 feet. The masonry was cracked in all directions owing to the settling of the abutments. The repairs were carried out by making cement injections in the proper way so as to consolidate the mass. At the side of each crack were bored holes of small diameter which did not however reach clear though the mass, so that the outer end was closed. At the same time the track rails were held off the arches by supporting them on independent I-beams. After cleaning out the holes by injecting water in them, a very fluid cement mortar was injected in under a pressure of 5 atmospheres by using compressed air, and this was left to act until the cement had been forced into all the cracks so as to fill them up. The holes were then stopped up with wood plugs until the cement became hard. In this way the whole construction was made solid and the result was very satisfactory. But a small amount of cement was needed, about 50 pounds per cubic yard.

In a paper read some little time ago before the Scientific Society of the Glasgow Technical College, Mr. F. L. Maclaren described an experiment by Mr. G. Tait, in which the necessary cooling of the furnace of a suction producer was effected by carbonic acid instead of by water vapor. In a preliminary experiment in which steam was passed into the producer in the ordinary way, a gas was obtained having a calorific value of 138 British thermal units per cubic foot. Supplied with this gas the engine developed as a maximum 106 horse-power. With a view to eliminating hydrogen from the gas the water supply was stopped, and the gas then produced had a calorific value of 91 British thermal units, and, used in this same engine, this gas developed 114 horse-power with ease until the fire in the producer became overheated. To stop this overheating Mr. Tait then passed some of the exhaust from the engine under the fuel bed of the producer, and at the same time, knowing the gas yielded would be free from hydrogen, raised the compression to 200 pounds per square inch. With this arrangement the producer operated quite satisfactorily, and the engine, with entire freedom from pre-ignition or back-firing, developed a maximum of 126 horse-power and ran under 110 horse-power continuously and with the greatest ease.

ELECTRICAL NOTES.

The Russian government intends to carry out electric railroad projects which amount at the least to a total of $20,000,000. One of the principal projects relates to using electric traction upon the city and suburban sections of railroad, and the government department recently asked a credit of $10,000 from Parliament in order to draw up the plans for this work. It is intended to carry it out by 1915, and the total cost of the enterprise is from $14,000,000 to $20,000,000. It is also proposed to build an electric railroad in order to connect the Finland railroad system with the Imperial railroads. A plan which may be carried out at St. Petersburg is the construction of a special electric line in order to interconnect all the railroad stations in the city. This would involve an outlay of about $16,000,000. In the south of Russia an electric railroad is to be built from Sebastopol by way of Ialta to Aluchka.

Measures have been taken to transform the whole of the electric lighting system of Paris. A new company now takes the place of the six independent companies, each of which had a separate area in charge. Owing to the difficulty of making the change, a temporary period is allowed for, and during this time the new company, known as the Paris electric distribution company, is to extend and improve the system of city mains. This transition stage will last until 1914, and at this date the company will be obliged to reduce its rates for lighting current in the proportion of 3 to 7, which will be of great benefit to consumers and no doubt lead to an increased use of electric lighting, as at present the rates are exceptionally high. The new system of underground mains will have three concentric areas known as zones, comprising the central and more densely populated region where the most current is used, also the middle zone, where the consumption is less, and the outlying zones. Direct current is to be used in the inner zone and alternating current in the two other zones. The plans call for the building of two large electric stations which are to produce 100,000 horse-power. While these are building the current will come from the large St. Denis station and other plants which lie mainly in the suburbs. Numerous substations are being erected in town in order to transform the alternating current for the mains, and at present these (including the existing substations) represent about 100,000 horse-power. At the end of last year the company had engaged in work involving an outlay of $16,000,000.

In an article published in the Phys. Zeitschr., K. Bangert points out that the function of the detector in wireless telegraph is to convert the high-frequency oscillations into some form of direct current, and this it effects to the best extent when the detector completely absorbs the oscillatory energy, or in other words when the detector circuit is completely aperiodic. The experimental investigation described comprises the galena detector, the electrolytic detector, and the coherer. Bangert concludes that the detector circuit should consist solely of the coupling coil, blocking condenser, and detector (and its auxiliaries—telephones or local circuit). These last two circuits act as dead capacities, and should therefore be put in shunt to the blocking condenser, where they have little influence. For the electrolytic detector the blocking condenser should be chosen fairly large; for instance, 5,000 centimeters. The coupling coil should be chosen of such inductance that with a detector (electrolytic) capacity of 200 centimeters, the mean wave-length of the tunable range is obtained. For 600-1,200-meter wave-length an inductance of 10^6 centimeters is ample, the circuit with electrolytic detector there giving a very flat maximum between 800 and 1,000 meters. Although this circuit is nearly aperiodic with the electrolytic, and quite so for the galena detector and the ticker, it is impossible to make it aperiodic with the coherer. In such case a variable condenser must be put in shunt to the coherer, as is generally done; but the other detectors require no tuning appliances, beyond a variable condenser in the antenna circuit for tuning it to the desired wave-length.

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TRADE NOTES AND FORMULÆ.

Casting Mass for Ornaments, Busts, etc.—Fifty parts of glue, 35 parts of wax or rosin, and 15 parts of glycerine, with about 30 to 35 per cent of mineral color. The glue, with the aid of steam, is dissolved in the glycerine in a boiler, the wax or rosin being added and finally the mineral color. The fluid composition used is for casting in molds.

Polishing Powder for Glass.—Rub calcined magnesia down with pure benzine, so that a mass is formed sufficiently soft to allow drops to be pressed out of it. This mixture must be kept in closely stoppered glass bottles to retain the very volatile benzine. A little of the mixture is placed on a pad of wadding or cotton and the glass rubbed with it.

Spot Removers for Grease Spots.—(*a*) Ammonia, 1 part; 95 per cent alcohol, 3 parts; ether, 3 parts. (*b*) Rectified oil of turpentine, 4 parts; 95 per cent alcohol, 1 part; ether, 1 part. (*c*) Soaproot, 2 parts, extracted with water, 30 parts; mix the extract with ammonia, 1.5 parts. (*d*) (According to Winckler.) Pinolin, 1 part; ether, 1 part; 95 per cent alcohol, perfumed with a little oil of bergamot. (*e*) (According to Le François). Soaproot, 64 parts; clarified lemon juice, 45 parts; alcohol, 185 parts; river water, 1,700 parts. (*f*) Soap, 1 part; ox-gall, 0.5 part; turpentine, 0.1 part. (*g*) Venetian soap, 1 part; ox-gall, 0.5 part; honey, 0.15 part; sugar, 0.1 part. (*h*) Benzole, 1 part; alcohol, 6 parts; ammonia, 2 parts.

To Gild Glass for Decorative Purposes.—Dissolve 1 part of fine gold (with traces of silver) in 10 parts of aqua regis (nitro-muriatic acid or gilders' aqua fortis), concentrate by evaporation until it sets, take it up with a little distilled water, separate it, by filtration from the chloride of silver formed, and dilute the filtrate to 200 parts. (From coin gold, the silver must first be separated.) On the other hand, dissolve 500 parts of crystallized carbonate of sodium in 3,000 parts of water, add 1,500 parts of slaked lime, and boil, until on the addition of hydrochloric acid to a sample, ebullition no longer occurs. After settlement, draw off the clear soda lye. Reduction fluids: (*a*) Into 1,000 parts of 80 per cent alcohol, through a glass tube drawn to a point, introduce illuminating gas for two hours, the higher the pressure the better; (*b*) dissolve 50 parts of white sugar in 300 parts of water, add 2 parts of strong nitric acid and boil for 10 minutes. In gilding, the glass surface is washed first with ordinary, then with distilled water, next with ammonia fluid, then with alcohol and distilled water, finally rub it dry. Now provide a glass plate of a larger surface than the one to be gilded, with a rim, 5/8 inch high, of wax, asphalt and tallow, a few pieces of glass being laid on the surface, the glass plate to be gilded is held at an angle over it, without the fingers touching its surface, the gilding fluid to be poured on the lower glass plate; then the plates are lowered into the solution. (Space between the plates should be 4 to 5 millimeters.) The gilding fluid must be mixed immediately before use: 200 parts fluid a, 75 parts fluid b, and 325 parts of distilled water. Of this mixture use 3 parts to 20 parts soda lye and 100 parts gold solution. The gold in powder form that is deposited on the lower plate is carefully rinsed off and recovered. To recover the gold from this solution it is acidified with hydrochloric acid and green vitriol added to it; the gold powder separated is washed, heated to redness, boiled in hydrochloric acid, filtered, and washed out.

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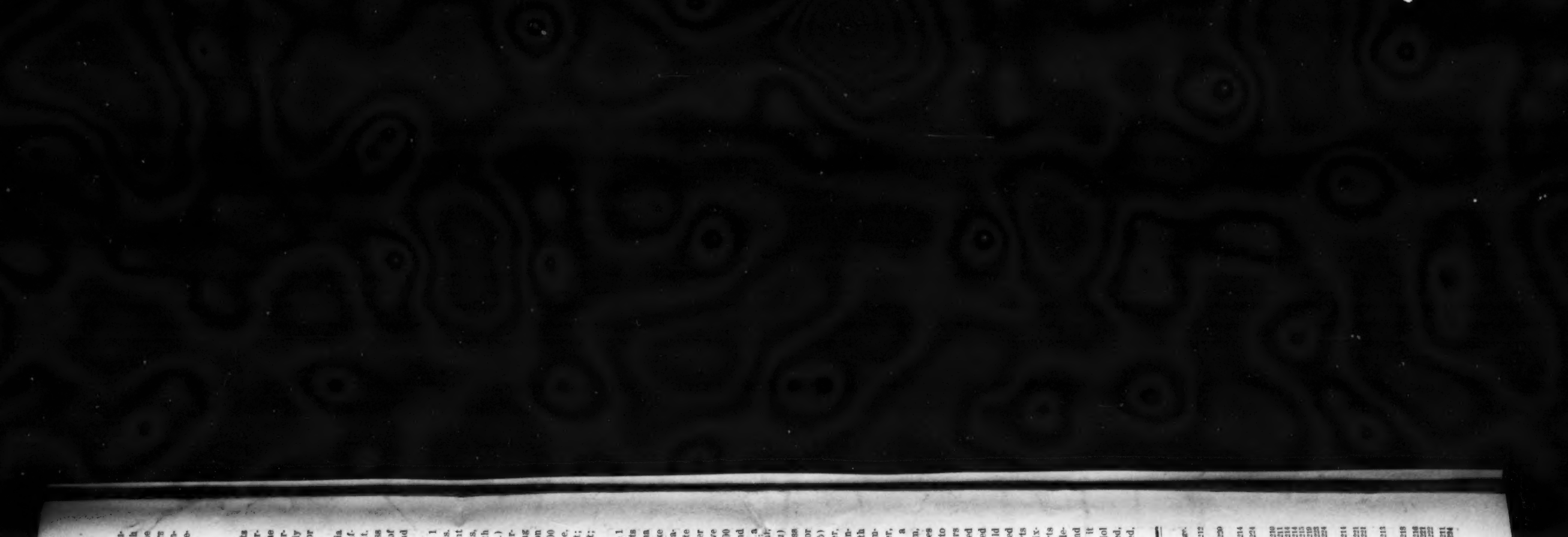
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